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ERRATA

Insert on p. 73 after Fig. 138:

Fig. 139. Portions of a transverse section of the blade near the margin. × 85.

PLATE 20

Fig. 140. Portion of a transverse section of the leaf sheath near its midrib. × 85.

Fig. 141. Photograph of a thin film of "kiskisan" rice bran. Slightly reduced.

Fig. 142. Portion of a transverse section of the mature intercalary meristem. × 85.

Fig. 143. Photograph of a thin film of sieved "kiskisan" rice bran. Slightly reduced.

Page 143, description of Clon 865 in table 1, "(Smooth Cayenne × Buitenzorg) F_1" should read "(Queen × Clon No. 28) F_1 spiny."

Page 165, line 10 from bottom, "*Types of tenancy centracts*" should read "*Types of tenancy contracts.*"

Page 183, line 3 from bottom, "I. An attempt is made to the determine the types of tenancy" should read "1. An attempt is made to determine the types of tenancy."

Page 189, entire line 8 from bottom, "FOURTH. (a) In case the crop planted is palay, the seed and all expenses" should read "THIRD. That whenever the tenant shall borrow money or any farm produce."

Page 263 (table 1) and page 287 (table 23), lot 42, "Madoao, Davao" should read "Madaum, Davao."

Page 304, line 2 from bottom, "annahernder" should read "annaehernder"; "Nahrstoffvorrats" should read "Naehrstoffvorrats."

Page 307, table 1, "Wasserkapasitat" should read "Wasserkapasitaet"; "Hygroskopizitat" should read "Hygroskopisitaet"; table 3, Nahrstoffvorrat" should read "Naehrstoffvorrat"; "Salzsaureauszüge" should read "Salzsaeureauszüge."

Page 391, Abstract, "Experiment Station contribution No. 1156" should read "Experiment Station contribution No. 1186."

Page 394, line 1, "Mr. Andres M. Mane, '39" should read "Mr. Andres M. Mane, '29."

Page 486, legend for text figure "*Spalgis substrigata* (Snellen)" should read "*Spalgis epius* Westwood subsp. *semperi* Fruhstorfer."

Page 487, lines 1 and 2 from top, "*Spalgis substrigata* (Snellen)" should read "*Spalgis epius* Westwood subsp. *semperi* Fruhstorfer."

Page 520, line 20 from top "37.33 ± 71.89" should read "37.33 ± 0.70".

Page 676, line 1 from top, "*Glomerella gossypii* South" should read "*Glomerella gossypii* (South.) Edgerton."

Page 676, line 18 from top, "*Heterodera radicicola* Greef" should read "*Heterodera radicicola* (Greef)."

MORPHOLOGY OF ORYZA SATIVA LINNAEUS [1, 2]

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and

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Of the Department of Agricultural Botany

WITH TWENTY-NINE PLATES AND ONE TEXT FIGURE

The vegetative and reproductive organs of the rice plant, *Oryza sativa* Linnaeus, have been the subject of study by many investigators. The works of Kuwada (1910), Haan (1911), Akemine (1913), Balsao (1925a, 1925b, 1925c, 1926-1927), Duval-Jouve (1875), Terada (1928), Selim (1930), Ishikawa and Shibuya (1930), Santos (1933), and Morinaga and Fukushima (1934, 1935) deal with certain phases of the anatomy, morphology and cytology of this cereal crop. Additional work on the anatomy and morphology of this economic plant is deemed desirable at present, since none of the existing publications gives a complete and sufficiently detailed picture of its true structure. This paper also includes some observations on the biological behavior of its flower.

The writers believe that, owing to the very diverse forms of *Oryza sativa* Linn. now existing, it will be unsafe to generalize on a limited number of these varieties; more so on a single variety. It was, therefore, deemed desirable to study a single variety in detail and eventually to follow this up with a comparative study of the minute anatomy of certain parts that would reveal usable differences for separation and identification of varieties.

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[1] Experiment Station contribution, No. 1175. Received for publication, February 17, 1937.

[2] The writers are appreciative of the encouragement and a few suggestions received from Dr. Bienvenido M. Gonzalez, Dean of the College of Agriculture, University of the Philippines, during the progress of this investigation.

[3] Formerly employed in the Department of Plant Physiology (now Department of Agricultural Botany), College of Agriculture, Laguna, as a student assistant in plant physiology working under the direct supervision of the senior author.

MATERIAL AND METHODS [4]

The material for study was grown in petroleum cans and in large earthen pots (pilones) behind the Laboratory of the Agricultural Botany Department from June to December, 1934, 1935, 1936. The seeds were planted in seed beds as usual and at the age of from 9 to 15 days the seedlings were transplanted to cans and earthen pots. The cultures were kept flooded with water as often as was necessary until about harvest time.[5] Collections of the material for embryological study were made at various intervals and these were killed and fixed in the field with the use of formalin-acetic-alcohol (70 per cent) and Bouin's aqueous solution prepared according to the formulae given by Chamberlain (1932). The material was treated as usual, embedded in paraffin, and cut into sections 8 to 10 microns thick. The sections were stained mostly in Heidenhain's iron-alum haematoxylin, with orange gold dissolved in clove oil as a counterstain.

Material for anatomical study of the vegetative organs was either embedded in paraffin or cut with a Spencer sliding microtome. These were stained either with the use of Heidenhain's iron-alum haematoxylin or safranin-Delafield combination and safrain-light green. Not infrequently temporary mounts were prepared, especially if the material proved to be too hard for paraffin embedding.

Maceration of the different parts of the mature grain was done with the use of Schulze's maceration fluid as described by Greenish (1923).

THE PLANT

The writers chose the Inapostol rice variety for their study because of the ease with which this form responds to either the paddy or dry condition. Besides, its yield records compare favorably with the majority of other standard and commercial rice varieties found in the Philippines. This variety which bears the Bureau of Plant Industry number "P. I. No. 1001," is supposed to be a pure strain isolated from Señora II in 1915 by the former Bureau of Agriculture, Manila (Borja, 1931) and is considered an early maturing, lowland,

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[4] For the privilege of free access to the photomicrographic outfit of the Department of Botany, College of Liberal Arts, University of the Philippines, and for the help rendered by Mr. Jesus Redondo of the same Department, the writers wish to express their gratitude.

[5] The seeds were obtained from the Division of Farm Crops, Department of Agronomy, College of Agriculture.

standard variety (Aragon, 1933). According to Borja [6], this variety is called Inapostol in Central Luzon and Senador in the Bicol provinces; this is commercially known now as Inapostol, although in some places it is called Apostol and Capostol. Much of the Inapostol crop is now raised in Nueva Ecija, Albay, and Camarines Sur. It matures in about 144 days, yielding from 30 to 70 cavans and sometimes as high as 84 cavans per hectare, or an average of 50 cavans to the hectare. Records of our three year plantings show on the average 143 days maturity, only a day less than that given by Aragon (1933). It is at present grown in Laguna, Cavite, Rizal, La Union, Leyte, and Palawan. In other provinces, such as Bohol, Iloilo, Samar, Occidental Negros, Batangas and Tayabas, this variety has, perhaps, been recently introduced.[7]

Description. This plant is somewhat low, and its leaf sheath is nearly glabrous outside, yellow green to calliste green towards the base and sometimes with a purplish tint especially on those sheaths borne near the last leaf; inside the epidermal as well as hypodermal cells, or only those epidermal cells found directly above the vascular bundles confined to about half the length from the base, contain amaranth purple color pigment.[8] The blade is narrow, linear-lanceolate, calliste green to yellow green, possessing few long to short, unicellular, hyaline hairs (Pl. 3, fig. 23; Pl. 4, fig. 31) and short unicellular sharp trichomes above the veins on the upper surface, glabrous below; margins serrulate half its way from its acute apex. The auricles are short, falcate, curved (Pl. 1, fig. 3 and 7), pale yellow, bearing two indistinct rows of long, slender, unicellular trichomes in alternate fashion: blade joint glabrous, pale green, shining. The ligule (Pl. 1, fig. 7) is rather long, thin, erect, pale green, and early turning colorless, membranous, glabrous, and split into two distinct lobes, the apices of which are acute. The internode is rounded, light viridine green to straw in color; node much larger or nearly so (Pl. 1, fig. 1 and 2), clear yellow green with sheath joint javel to neva green. Sometimes, the sheath joint possesses two distinct circular bands of purplish color. The last leaf or flag is nearly always erect, mineral green to calliste green, shorter than the tip of the

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[6] BORJA, V. Studies on some important characters of commercial varieties of rice in the Philippines. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1934. Unpublished).

[7] Based on collections of the senior author.

[8] In the determination of the color of the vegetative parts of this rice variety, Ridgway's (1912) *Color Standards and Color Nomenclature* was used.

inflorescence, broader than the blade of the lower leaves, rough above, glabrous below, margins serrulate to nearly two-thirds from its acute apex.

The inflorescence is erect, close, small, far-exserted to exserted. The peduncle is terete (Pl. 1, fig. 4), light javel green; rachis, rachillae and pedicels, calliste green. The spikelet is obovate or oblong to elliptic-oblong, borne on a slender pedicel; lemma and palea hirsute, light viridine yellow; apiculus dark purple, erect; glumes small, glabrous, shiny, colorless to pale green; stigmas two, black purple, plumose; stamens six, anthers cylindrical, bilobed, borne on long, cylinder, hyaline filaments; lodicules two, colorless, membranous and boat-shaped. Weatherwax (1929) has observed few spikelets of rice with imperfectly developed or deformed stamens; in one flower are present seven stamens, the extra one being borne as a basal branch of one of the normal six.

The mature panicle is nodding and close. The grain is slender and oblong; glumes small, shiny outside, straw color; lemma (palea inferior) and palea (palea superior) hispid, straw color; apiculus straight or erect, straw to nearly purplish in color. Its caryopsis or kernel is oblong, white, flinty, wholly corneous or nonglutinous. This measures about 5.87 to 6.86 millimeters in length, 2.21 to 2.43 millimeters in breadth, and 1.57 to 1.78 millimeters in thickness.

THE ROOT

It is universally known that the root differs from the stem by two structural features, namely, the possession of a root cap and the radial arrangement of its vascular bundles. The root cap, which is usually colorless, occupies the extreme tip of the root, but this may sometimes be colored, when it could perhaps be taken as a sign of pathological disturbance.

A cross section of a young root (Pl. 16, fig. 123) shows a cylinder of vascular tissue limited on the inside by a poorly developed pith (Pl. 24, fig. 163), while on the outside, by the endodermis and the cortex. The pith is rather small and consists of uniform, large, nearly spherical to polygonal cells which are elongated vertically and are inclined to become somewhat larger towards the center. The cortex possesses on its inner and outer periphery layers of small, specialized cells. That at the outer periphery (Pl. 16, fig. 123 and 124; Pl. 24, fig. 161) is a specialized layer of small, narrow, elongated, thick-walled, prosenchymatous cells and form in their entirety a distinct sclerenchymatous cylinder. The row of cells (Pl.

16, fig. 124) at the inner periphery consists of square cells, which later show a tendency to thicken their walls very irregularly (Pl. 24, fig. 163 and 164). The rest of the cortex is composed of large, rounded or hexagonal to rhomboidal cells, which are arranged in rows (Pl. 16, fig. 123), and these tend to become smaller inward. Between these cortical cells are found rhomboidal intercellular spaces. These cortical cells later disintegrate with the formation of large air spaces or chambers (Pl. 16, fig. 124; Pl. 24, fig. 161).

The epidermal cells are vertically cylindrical. Many of the epidermal cells grow into root hairs, which may remain attached to the root long before they have ceased to function. Beneath the epidermis is the cortex. The outermost cortical cells, the exodermis, consist of a layer of thin-walled cells (Pl. 16, fig. 123), which are often larger and more elongated than the cells of the epidermis. These exodermal cells are rectangular to squarish in transverse section and elongated vertically, forming a specialized cover to the root at the death of the epidermal cells (Pl. 24, fig. 161). The walls of the exodermal cells are often suberized, and their inner tangential walls are often thickened. These may also die and slough off, after which the protective function becomes relegated to the sclerenchymatous cylinder below.

The rest of the cortical cells inward degenerate into the large air chambers referred to above, separated by long continuous or discontinuous bands of degenerated and collapsed cortical cells, leaving practically a single layer of cortical cells intact below the sclerenchymatous cylinder (Pl. 24, fig. 161) and another layer above the endodermal cells (Pl. 24, fig. 163). To these persistent cortical layers of cells the long, degenerated, linear rows of cortical cells separating the air chambers remain attached, resembling the spokes of a wheel (Pl. 16, fig. 124).

The endodermis consists of a single layer of cells (Pl. 24, fig. 163; Pl. 25, fig. 166) connected uninterruptedly with one another. The individual cells are vertically elongated, four-sided prisms with horizontal end walls. Their radial walls are slightly thickened and are usually slightly longer than, but sometimes as long as, their tangential walls. The cells are thin-walled in their meristematic state but upon maturity their inner tangential walls and parts of their radial ones become greatly thickened and lignified (Pl. 24, fig. 164). The Casparian strips so often reported in young endodermal cells in other grasses and in dicots may be found only with difficulty in the material examined by the writers.

The vascular tissue (Pl. 16, fig. 124; Pl. 24, fig. 163; Pl. 25, fig. 166) consists of alternating masses of primary xylem and phloem, which occupy different radii. The xylem plates nearly reach the center of the root, which is occupied by the pith. In young roots there are always four large vessels formed; in older ones, however, this number may remain the same or may increase to six in rare cases. The clusters of protoxylem and phloem are numerous, a result of the absence of secondary growth so peculiar to dicotyledonous plants. In thin lateral and branch roots (Pl. 25, fig. 168) and fine rootlets (Pl. 24, fig. 165) of seedlings, the xylem plates are very few, the pith being totally crowded out and practically non-existent. The groups of xylem are separated from the endodermis by a single layer of pericyclic cells (Pl. 24; fig. 163), but in small roots the xylem cells may occasionally border directly the endodermis. Between the xylem and the phloem are parenchymatous cells, usually one layer thick and often surrounding the xylem. These parenchymatous fillers are not so extensively developed as those reported for sugar-cane root (Artschwager, 1925), due perhaps to the relatively smaller size of the roots of rice. The thickenings of the parenchymatous cells, as well as that of the pith cells, may commence after the protoxylem is formed, and while the large vessels are still meristematic. The walls of pith cells thicken first, and thickening progresses centrifugally. In mature roots all the tissues of the vascular cylinder except the pericycle and the phloem cells become thickened (Pl. 24, fig. 164).

In branch roots and small fibrous rootlets the cortex, as well as the vascular tissue, are poorly developed. In branch roots (Pl. 25, fig. 168) the cortical layers are comparatively few and the exodermis and sclerenchymatous layer are easily detectable. The endodermis is also distinct, but the metaxylem vessels, as well as the phloem portions, are poorly developed and at maturity the walls of all the cells in the vascular cylinder become strongly lignified. In fine rootlets (Pl. 24, fig. 165) the exodermis and the outer sclerenchymatous cylinder formed in the cortex are not conspicuous and are almost always absent, the cell layers being reduced almost to three or less. The endodermis is still present and its vascular tissue is small, the pericyclic cells being the largest among them.

The young radicle (Pl. 27, fig. 178; Pl. 28, fig. 182) presents a structure similar to those described above for young roots (Pl. 16, fig. 123). However, at its basal portion and where connection with the vascular supply to the plumule and scutellum has to be made, the

epidermis and cortex disappear, and the regular arrangement of its vascular bundles in the stele is destroyed (Pl. 28, fig. 180).

Adventitious and branch root formation. At an early stage in the development of the rice seedling, the only absorptive organ is the radicle. Later, however, adventitious roots arising from the lower nodes are formed so that, as the seedling develops, it becomes well provided with numerous adventitious fibrous roots, while its radicle degenerates, a feature so prominent among cereals in general. The earliest time that primordia of adventitious roots arising from the lowermost node become microscopically visible was five to six days from planting the seeds in seed bed, and when their radicles and plumules were six to eight centimeters and one and a half to two and a half centimeters in length, respectively (Pl. 16, fig. 125). From this time on, formation of similar root primordia took place at every node close to the growing apex of the stem.

Branch roots from the radicle are detectable under the microscope when it has attained a length of about two centimeters and the plumule, about one centimeter (Pl. 16, fig. 126).

A very interesting feature worth mentioning is the development of long, hyaline prolongations of the epidermal cells of the embryo covering the plumule and radicle during the early stage in the germination of the rice grain (Pl. 23, fig. 158). These hairs are diagrammatically illustrated by Bernegg (1929). Whether these hair-like elongations of the epidermal cells of the embryo function in the actual absorption of water during germination, the writers are not certain. These lateral epidermal prolongations from the embryo are ephemeral in nature, and are usually gone by the time the radicle has attained a certain length and has completely emerged from the grain. It seems, however, that from their positions and anatomical features, these hairs may actually absorb water from the soil during the time the radicle is still undeveloped, as shown by the fact that they are absent by the time the radicle has emerged from the germinating embryo.

Development of primary tillers. According to Ramiah and Narasimhan (1936), tillering in rice commences about two weeks from planting and will be in full swing for three to five weeks, depending on the variety. The 'critical period' of tillering, however, is considered by these investigators to have been reached two to three weeks before the maximum tillering phase is attained. Microscopically, in the axil of every leaf is borne a dormant bud (Pl. 17, fig. 127; Pl. 28, fig. 179), the forerunner of a branch or tiller primor-

dium. The trend of development of these primordia seems to be acropetal. This lowermost bud forms a primary tiller; those borne on the upper portion of the main axis develop only when the plant has reached nearly complete maturity or when the stubbles are left in the field after harvest. These are, however, better described as branching.

The first sign of activity of the lowermost axillary bud in the seedling was found at the time the seedlings have reached a height of about 25 centimeters, measuring from the grain to the tip of the longest young leaf (Pl. 17, fig. 128). At that stage, that is, seven days after transplanting, the coleoptile has already disintegrated. The first tiller becomes visible out of the subtending leaf in about twenty-four to thirty days after transplanting or thirty-one days to thirty-seven days after soaking the seeds in water and sown in seed beds. The development of the subsequent tillers of the second, third, and further degrees were not followed by the writers, as these have been extensively studied by Katayama (1931).

THE STEM

In nearly all cases the specimens for study on the anatomy of the stem were taken midway between the base and the growing point of the axis. The internode is nearly uniform in size, though somewhat larger at the basal portion. The node is slightly thicker or nearly as large as the internode (Pl. 1, fig. 1 and 2), from whence it enlarges, owing to the presence of the basal portion of the leaf sheath (sheath joint). Above the node and where the intercalary meristem is situated (Pl. 1, fig. 2), it is greatly smaller in diameter.

A transverse section of the internode, midway between the two contiguous nodes, shows numerous vascular bundles which are arranged in two distinct bands and embedded in the ground parenchymatous tissue (Pl. 18, fig. 132). The central portion of the stem is hollow, whence the name culm or haulm. Externally, the stem is limited by a layer of epidermis, the cells of which are somewhat squarish to rectangular, with their outer tangential walls nearly concave in transverse section. Below the epidermis are two to four layers of small, hexagonal cells constituting the thin cortex; this is followed by a mass of larger, rounded, hexagonal to rhomboidal, thin-walled cells of the pith wherein the vascular bundles are located. These pith cells may sometimes be rounded to somewhat elliptical, whereas cylindrical in longitudinal section with their end walls straight or somewhat rounded. The depth of the cells varies with

their position on the stem; those in the internode being more elongated near the vascular bundles, but in the node the cells are very short, regardless of their radial positions. These parenchymatous cells serve as fillers between the vascular bundles; small intercellular spaces separate these ground parenchymatous cells.

The cortex forms a narrow band of tissue, except at the node, where it may be thicker (Pl. 19, fig. 135). In the internode two to four layers of cortical cells seem to form a continuous mantel. In the node, on the other hand, this may consist of from four to six layers or more. These cortical cells become thick-walled and lignified as the stem approaches maturity. The cortex is followed inward by several rows of thin-walled parenchyma, the cells of which remain cellulose even in the old and lignified stem. There is a gradual transition from the cortical cells to those of the bundle parenchyma. The cells of the transition zone grow progressively larger centripetally, their walls becoming gradually lignified wholly or in part. These parenchyma fillers separate the vascular bundles from the cortex proper. The rest of the parenchyma in the pith are large and densely filled with an abundance of starch grains, a character so conspicuous with rice.

Portions of the ground parenchyma fillers between the radial rows of vascular bundles in the internode often degenerate with the consequent formation of large air chambers (Pl. 18, fig. 132) which are absent in very young stem (Pl. 26, fig. 171). When the stem is young, it is solid (Pl. 17, fig. 127). The central portion of the stem is occupied by loosely packed parenchyma which have large air spaces between. By gradual degeneration accompanied by active resorption, the central portion of the internode becomes hollow.

The lowermost internode (Pl. 23, fig. 154) shows a structure and arrangement of vascular bundles quite different from that described above. The vascular bundles lie nearer the interior, close to the hollow portion inside. The definite arrangement of the bundles described above is somewhat lost. Instead, the bundles seem to lie in three indistinct bands. The outermost band of vascular bundles is somewhat rounded to oblong, exhibiting two to four large vessels, the protoxylem vessels being indistinguishable. These bundles lie far apart. The innermost band of vascular bundles is usually larger and these lie rather close to each other and tend to show the formation of distinct protoxylem lacunae. These may be oblong to trapezoidal with their long diameters radial to the stem. In fact, these inner bundles come so close to the hole that only one to two layers of

parenchyma intervene between the hole and the bundles. The vascular bundles in the middle band are small, poorly developed, and are very irregular in distribution. These bundles possess few xylem and phloem elements and distinct sclerenchyma sheaths. About half of the section is occupied by distinctly large rhomboidal to oblong parenchyma, these being smaller ectally. Large lacunae or air chambers are found just outside the bundle regions, and these are very conspicuous in the section.

Storage of starch takes place mostly in the stem, which organ becomes, perhaps, the principal seat for storing reserved food in the vegetative body. This is to be expected because in rice the leaves, with the exception perhaps of the terminal one, the flag, usually show earlier signs of death than the stem.

Chloroplasts are found in the parenchymatous cells below the sclerified cortical and epidermal cells of the internode, much more numerous towards the periphery and fewer inward. If coloration in the internode is present, as is true in many varieties of our rice, the pigment is generally confined to the epidermal cells above the vascular bundles, and in rare cases in all the epidermal cells.

Epidermis. Typically, an epidermal layer is present forming an outer covering of cells around the stem, this possessing stomata and very often producing outgrowths or hairs. In this particular variety under study the trichomes or hairs are sparingly developed on the stem.

The epidermal cells are remarkably uniform in size and shape. The individual cell is a four-sided prism with its walls thickened and somewhat undulated (Pl. 2, fig. 12). The cells above the vascular bundles are more elongated than those found between the bundles. Two distinct kinds of cells are found in the epidermis. The long rectangular cells with undulated walls which are often pierced by minute numerous pits easily seen in sections treated with glycerine or similar mounting agents, have their long diameters parallel to the long axis of the stem. Their walls are thickened and heavily cutinized. The smaller cells which are transversely rectangular, are found in pairs or singly in very few cases. Artschwager (1925, 1930) also detected the presence of small, paired epidermal cells in the internode of mature stem of sugar cane, and he called one of them cork cell and the other silica cell. The silica cell is biscuit-shaped and varies little in size and form in the different varieties of sugar cane he examined. In some varieties this cell may be wanting. On the other hand, the cork cell is reniform, rectangular, trapezoidal or

elongated. The presence of the last kind of cork cell is more or less restricted to certain sugar cane varieties. In fact, Artschwager believes that sugar cane varieties can be conveniently separated by the structure of the internodal epidermis of their stems, because this organ appears to be little influenced by environmental factors. The importance of internodal epidermal structure in rice as a guide to the identification of rice varieties is at present still doubtful, but the meager data at the disposal of the senior author seem to indicate its possibility in future studies.

In the intercalary meristem, the epidermal cells are very irregular in shape (Pl. 2, fig. 15). The cells become much less shorter than those found at the middle portion of the internode. Their walls are also irregularly thickened. Found among them and often alternating are somewhat oblong to rounded, thickened cells possessing knob-like protuberances at their centers. The walls of these smaller cells are much more even in thickness than those from cells devoid of the knob-like outgrowths

At the nodal region, the epidermal cells (Pl. 2, fig. 13) are much longer than in either the internode or the intercalary meristem. Here the cell walls are comparatively much more thickened and prominently pitted.

The stomata (Pl. 2, fig. 14) possess two dumbbell-shaped guard cells, each subtended by distinct subsidiary guard cells. These stomata are arranged in rows between the vascular bundles. Above the bundles stomata are absent. In the node and intercalary meristem, the writers found no stomata.

The trichomes on the internode are of two types. They may be one- (Pl. 2, fig. 16) or two-celled (Pl. 2, fig. 11). These trichomes usually arise from small epidermal cells which may either be rounded or oblong, and are absent in the node and intercalary meristem.

Peripheral bundles. The peripheral bundles are situated near the cortex in the internode (Pl. 18, fig. 132). The bundles may be rhomboid to oval, with their long diameters at a tangent to the stem. A sclerenchymatous sheath surrounds each bundle, and this is usually thicker towards the radial and inner tangential sides of the bundle. At the intercalary meristem these peripheral bundles are situated farther from the epidermis (Pl. 18, fig. 131; Pl. 20, fig. 142). Broken or continuous strips of sclerenchymatous cells develop from the inner portions of these bundles. These sclerenchyma strips may be found running around the inner tangential sides of the masses of thin-walled cells. The phloem is rounded, consisting of few sieve

tubes and companion cells, and surrounded by few parenchymatous cells. The two lateral metaxylem vessels are present, between which is located an annular protoxylem vessel. The protoxylem lacuna is very often wanting. The sheaths of the vascular bundles often abut and fuse with the sclerenchyma cylinder of the cortex. In the intercalary meristem these peripheral bundles are often distally separated from the cortex by few to many layers of parenchyma (Pl. 18, fig. 131; Pl. 20, fig. 142).

The peripheral bundles lose their identity in the nodal region (Pl. 18 fig. 135). They appear to break up into smaller bundles of various sizes and configurations, which, together with the other bundles already present in the internode, form a comparatively broad zone of small to large vascular-bundle groups. The bundle sheaths of these bundles show greater development at the phloem poles than at the xylem poles.

At the intercalary meristem the sheath cells form throughout the stem a winding band of sclerenchyma around the regions where the cells actually degenerate in the internode; the lacunae or large air chambers are absent. However, at regions where these air chambers ought to have been formed, the cells remain thin-walled, and slightly lignified. When leaving the nodal region, the peripheral bundles become more uniform again. The bundles continue to show the large lignified sheaths but there is no longer that mazed bundle fusion and splitting found in the lower zone. Above the node and in the intercalary meristem the structure and arrangement they possess in the internode is again attained.

Inner bundles. The inner bundles are oblong to oval, with their long diameters radial to the stem (Pl. 18, fig. 132). Each bundle is surrounded by a sclerenchymatous sheath which is strongly developed at both xylem and phloem poles, although at times its lateral portions may contain a considerable amount of sclerenchymatous cells. The xylem and phloem are collaterally disposed in relation to one another. The protoxylem consists of annular and spiral elements, below which is a protoxylem lacuna, a lysigenous cavity, into which often project the remains of the first formed annular vessels. Above and lateral to the protoxylem are two large metaxylem vessels with medium long articulations which communicate with them by a single large pore. These vessels are surrounded by tangentially flattened parenchymatous cells which may possess reticulate thickenings at maturity. The tissue between the two large vessels is composed of parenchyma.

The protophloem lies farthest to the outside. The cells of the bundle sheath are in direct contact with the protophloem; the other phloem cells are separated from the bundle sheath by a layer of small, elongated parenchymatous cells. A similar band of cells one to two layers in thickness, separate the phloem from the xylem. The phloem region consists of large hexagonal sieve tubes and rectangular smaller cells, the companion cells.

The bundle sheath forms a layer of cells devoid of intercellular spaces. The cells are elongated, thick-walled, and sparingly pitted. Their end walls are pointed, except at the junction of the xylem and phloem; here the sheath cells not only have shorter vertical diameters, but also their end walls are nearly transverse.

The bundles follow a longitudinal course in the internode, and are parallel to each other, except at the node, where a number of them may branch or bend abruptly and move towards the periphery. Many of the bundles, however, pass on to the next internode with but slight deviation from their former course (Pl. 27, fig. 175). Nevertheless, the structure of all the bundles is altered when passing the node.

The interesting appearance of the nodal bundles when viewed under the low power of the microscope is produced by the parenchyma adjoining the sheath. The parenchymatous cells bordering the sheath are somewhat enlarged, and are arranged around the bundle in a nearly stellate fashion (Pl. 22, fig. 150). The stellate arrangement of these parenchyma around the nodal bundles of the sugar cane stem (Artschwager, 1925) is much more marked. The nodal bundles lack the protoxylem lacuna and there is a general increase in the number of protoxylem elements. The phloem also shows on the whole an appreciable increase in size over those located in the internode. The phloem cells, however, have the tendency to become lignified and perhaps non-functional. The extent of lignification varies, but it seems to be in direct proportion to the size and age of the bundles.

As the bundles leave the node and enter the intercalary meristem, they change back to their old form. The stellate parenchyma disappear and the protoxylem lacunae again appear (Pl. 18, fig. 131; Pl. 20, fig. 142). Changes in the vascular sheath include an increase in development of a cap on the xylem pole of the bundle and the reduction in the cap at the phloem pole. The phloem shows little or no alteration. There is still a great deal of lignification, which is here sometimes more pronounced than in the nodal region.

Before the stem has reached its greatest length in its internode, lignification of the bundle cells in the intercalary meristem is somewhat suppressed, but as the internode reaches maturity and that all the meristematic cells have completely mature, then lignification sets in. The chief divergence from the normal structure consists in the transformation of sclerenchyma bundle caps into collenchyma and in a general reduction of the lignified cells of the vascular parts of the bundles.

Special features. At the nodal region the vascular bundles (Pl. 18, fig. 135) are more crowded together. Around the center where the pith cells never become destroyed (Pl. 27, fig. 175) as in the internode (Pl. 18, fig. 132) and intercalary meristem (Pl. 18, fig. 131; Pl. 20, fig, 142), are present in a ring a row of rounded to oval bundles. Towards the periphery and forming the middle band of bundles are the crowded ones forming groups of two to four, each group being connected together with highly developed band of sclerenchyma. The outermost band of bundles are small, comparatively few and rounded, each having strongly developed sclerenchyma caps at their phloem poles.

Some bundles are cut longitudinally in transverse section (Pl. 26, fig. 172) and these seem to have circuitous way around the nodal region. In longitudinal section these bundles exhibit very poor development of sclerenchyma sheath in their juvenile condition (Pl. 27, fig. 175). One to two metaxylem vessels are present, while the phloem is fairly well developed.

Adventitious prop-roots. Development of prop or aërial adventitious roots on the stem of rice is not uncommon. This is especially true with paddy rice when maturity is approaching and water in the field is not completely withdrawn. These adventitious root primordia appear at the upper portion of the node just below (Pl. 17, fig. 130) and also just above the insertion of the sheath or at the lower portion of the intercalary meristem (Pl. 17, fig. 129). Development of root primordia takes place at every node and in the intercalary meristem on the stem of this variety of rice under study and these only become apparently inconspicuous at the third node below the flag. Adventitious roots become macroscopically visible at the lower nodal regions of the stem when water is plentiful and deep in the field. The lower band of roots can easily emerge from the stem but the upper ones have to penetrate the leaf sheath before they could be visible from the outside, Unlike sugar cane (Artschwager, 1925) where two rows of root pri-

mordia are formed at the region above the leaf sheath (Keimring), in rice at least in Inapostol variety, an analogous number of rows of root primordia but occurring in different portions of the stem, is present.

LEAF SHEATH

A transverse section of the leaf sheath about midway between the sheath and blade joint, shows the presence of two bands of vascular bundles arranged in alternating radii and embedded in a fundamental parenchyma (Pl. 21, fig. 149). The cells of the fundamental tissue become broken at regular intervals (Pl. 20, fig. 140) so that the vascular bundles are actually separated from one another by large air cavities. The vascular bundles lie closer to the outer epidermis (morphologically the lower) than to the inner one. The large bundles are found lying farther from the outer epidermis, while the smaller ones lie nearly in close proximity to the outer epidermis. The bundles, whether small or large, have the typical shape described for the bundles in the stem; the larger bundles are radially oblong, while the smaller ones are nearly oval to ovoid in cross section. The entire bundle is surrounded by a sclerenchyma jacket, a continuation of the sheath of the stem bundle. The smallest bundles, which always lie closer to the outer epidermis, contain no protoxylem lacunae.

The midrib of the sheath shows the presence of a central strand of parenchymatous cells, three to four layers thick, running from its dorsal (outer) to its ventral (inner) surface and from this central strand several other strands of parenchyma, ranging from three to as many as eight layers of cells, branch out towards the outer epidermal layer. Near the inner epidermis are found masses of sclerenchyma at every place where the parenchymatous strands are supposed to join the epidermis. Similar masses of sclerenchyma are found towards the outer epidermis. In these strands of parenchyma and towards the outer epidermis are found embedded the vascular bundles similar to those found in the rest of the sheath.

When young the whole sheath is completely filled up with parenchyma (Pl. 21, fig. 149). The mass of parenchymatous cells which form the radial prolongations of the bundles in the direction of the inner epidermis shows distinct arrangement and these cells are filled up with an abundance of starch grains. Those lying between these parenchyma are devoid of starch and are the ones which degenerate and give rise to the large air cavities referred to above. With the exception of about three to four layers of parenchymatous cells towards the inner and outer epidermal layers (Pl. 20, fig. 140),

all of them degenerate in the formation of air cavities. The parenchyma, which form the radial prolongations of the bundles and which usually persist, terminate into small masses of sclerenchyma adjoining the outer epidermis. At the inner epidermis similar but smaller masses of sclerenchyma are also present.

The large air cavities are often intercepted horizontally by distinct layers of stellate cells into which bundles often project (Pl. 3, fig. 24a; Pl. 20, fig. 140). These bundles often connect two vertically directed bundles and are often spoken of as the commissural bundles.

The base of the leaf sheath, also called the sheath joint, is not as swollen as that found in the sugar cane. A transverse section through the sheath joint above its insertion to the stem (Pl. 22, fig. 151) shows also the presence of air chambers which are much smaller and less extensively developed than those found a few centimeters above the sheath joint. There are also present two bands of vascular bundles. The inner band is composed of larger bundles on the phloem poles of which are found great development of sclerenchyma caps. These large bundles occupy nearly the middle of the sheath. The outer band consists of much smaller bundles, entirely surrounded by well developed sclerenchyma sheaths at the center of which are few elements of the xylem, the phloem being indistinctly present. There is an absence of distinct masses of sclerenchyma found near the two epidermal layers opposite the vascular bundles. The lacunae are often developed between the large bundles and in the same radii occupied by the smaller bundles. These are found near the inner epidermis.

At the region where the sheath is just departing from the stem, the two bands of vascular bundles referred to above are easily detectable. The sheath shows development of radially elongated, oblong to rectangular thin-walled cells, possessing an abundance of starch grains. At certain portions, the development of the lacunae is evident; on the whole the sheath is solid.

The uppear portion of the sheath also undergoes modification before it emerges into the blade. As the sheath approaches the blade joint (collar), it becomes a bit narrower and thicker, thereby crowding the vascular bundles more and more. The middle portion becomes thicker, and approaches that of the blade joint. The vascular bundles located towards its margins often emerge into the ligule direct, and also to the auricles.

The blade joint of this rice variety is often colorless to pale yellow, while in other varieties this is often colored with varying degrees of purple and red. The blade joint has a distinct shape very different from the sheath joint. The shape is very similar to that of the midrib of the blade (Pl. 22, fig. 152) except that it is more oblong, while that of the midrib is nearly triangular. Running through the middle of the blade joint is a thin strand of from three to four layers of parenchyma (Pl. 19, fig. 138) and branching laterally from this are numerous strands of parenchyma radiating to the periphery of the blade joint. These anastomosing cell strands give the blade joint a spongy appearance. At every base of the individual parenchyma strand where it joins the epidermis is a single vascular bundle. The larger bundles are at the bases of the anastomosing membranes; and between them are the smaller bundles. Usually a small bundle alternates with a large one, but towards the upper flattened portion there are usually present two small bundles; at this upper flattened portion there are three bundles present. The bundles generally exhibit greater development of sclerenchyma caps at their phloem poles and are similar in structure to those found in the stem. The epidermal cells are small, and their outer tangential walls have the characteristic outgrowths which are prominently developed on the lateral and basal portions of the blade joint, but evidently absent on the upper portion.

The inner epidermis of the sheath differs fundamentally from the outer epidermis in that the cells of the former are larger, uniformly rectangular to oblong and of one type (Pl. 3, fig. 20). The walls are thin and straight. The epidermal cells above the bundles are somewhat narrower and more elongated than those found between. The stomata are present in rows and hairs are sparingly developed.

The cells of the outer epidermis (Pl. 2, fig. 17 and 19) resemble those found in the epidermis of the blade, although the former may be larger and longer. Their walls are wavy and comparatively thick-walled. The short cells are very conspicuous, occuring singly or in pairs (Pl. 2, fig. 17). The cells above the bundle are very much elongated and narrow; they possess hardly any lumina while those between the veins are broader, but otherwise they are structurally the same. Two types of trichomes are found on the outer surface of the sheath. The unicellular trichome (Pl. 2, fig. 18) is short and thick-walled. The two-celled trichome (Pl. 2, fig. 10) is very much

longer and slender. Stomata are present and their shape, arrangement and size are similar to those found in the blade.

The epidermal cells at the sheath joint (morphologically the lower surface) are more or less trapezoidal to rectangular, with relatively straight walls (Pl. 3, fig. 21). The small cells are apparently neither well developed nor differentiated. Their walls are rather thick, although comparatively thinner than those found in the sheath.

The outer epidermal cells of the blade joint (Pl. 3, fig. 26) are more or less rectangular and thin-walled. Pitting is conspicuously absent, although dwarfing of the cells is noticeable. Those dwarf cells are represented by the colorless cells in the figure.

THE LIGULE

The ligule is situated at the upper portion of the blade joint, the distal lateral portions being continuous with the sheath (Pl. 1, fig. 7). It is thin, hyaline and colorless, long, membranous, partially to entirely divided, acute to acuminate and glabrous. It contains vascular bundles scattered in a fundamental ground parenchyma (Pl. 25, fig. 167). In transverse section it is somewhat thicker at the middle region and tapers very gradually towards its margins. The outer epidermis (morphologically the lower) consists of ovoid to oblong cells in transverse section, with their long diameters parallel to the long axis of the ligule. The inner epidermis (morphologically the upper) consists of large, ovoid to oval or often rounded cells. Both epidermal cells have rather thick outer tangential walls which are highly suberized. Unlike the ligule found in sugar cane, that of rice possesses no lateral appendicular hairs, but vascular bundles are present, while these are absent in the sugar cane (Artschwager, 1925).

The vascular bundles occupy the space between the two epidermal layers. Each possesses very few xylem and phloem elements, and is surrounded by a layer of bundle sheath cells which are fairly thickened on their walls. The mesophyll portion of the ligule is occupied by two to three layers of large, rounded to rhomboidal or oblong parenchymatous cells, between which are small intercellular spaces. These cells are often devoid of pigment very early in their life, but in some varieties of rice, like Ballatinao from the northern provinces, the epidermal and mesophyll cells contain the purple-red pigment.

Stomata and hairs are absent on the ligule.

THE AURICLE

The auricles are two, small, ear-like appendages (Pl. 1, fig. 3, 7), borne at the sides of the blade joint, and usually arise at the junction between the ligule and the blade. These are usually curved inward, bearing along their dorsal sides throughout their lengths two series of somewhat alternate, long, unicellular, tapering, thin- to thick-walled, hyaline trichomes, or hairs (Pl. 1, fig. 3). If pigment is present on the auricles as is true to some rice varieties, the pigment is confined to the epidermal cells, but not to the trichomes.

A transverse section of the auricle shows that it is somewhat oblong (Pl. 18, fig. 133; Pl. 19, fig. 137), with its two sides nearly rounded. Surrounding it is a layer of epidermal cells, consisting of small, rather thick-walled, rectangular to oblong cells, with their long diameters parallel to the long axis of the auricle (Pl. 19, fig. 136). There are present two distinct vascular bundles at its middle portion (Pl. 18, fig. 133); these bundles are embedded in a mass of rounded to rhomboidal parenchyma, which are small at the periphery and larger centripetally. The vascular bundles are not well developed (Pl. 19, fig. 136); each possesses few xylem and phloem elements, surrounded by a distinct sclerenchyma sheath. At the region towards its base there are three distinct vascular bundles departing from the sheath (Pl. 1, fig. 3), but two of them fuse (Pl. 19, fig. 137) at a short distance from the base of the auricle (Pl. 1, fig. 3; Pl. 18, fig. 133), so that only two are encountered at its middle portion. These two bundles ultimately fuse a short distance from the middle.

The auricles are not persistent on the leaf and they easily slough off with slight mechanical pressure, because they ultimately become very brittle to the touch. This accounts for their absence in mature or nearly mature plant.

LEAF BLADE

The tissues of the leaf blade are continuous with those of the leaf sheath, and are generally of the same structural features. Differences, however, exist to suit the blade with the function that this organ has to play in the economy of the plant.

The vascular bundles are of two distinct types (Pl. 23, fig. 156); the small, nearly rounded bundles occur in fours at the middle of the blade before the large bundle is reached (Pl. 27, fig. 176), two to three of these before reaching the midrib, and usually one from the

margin before reaching a large bundle (Pl. 19, fig. 139) in the direction of the midrib. The larger bundles are, therefore, far from each other.

The bundles of the blade differ from those in the stem in that they possess chlorophyll-bearing sheaths and an inner sclerenchymatous sheath (Pl. 23, fig. 156), the latter consisting of only one layer of cells. The chlorophyll-bearing bundle sheath is made up of large, uniform, spherical cells, which are vertically cylindrical in form. Very often the inner bundle sheath is wanting, especially in the smaller bundles, and the xylem and phloem elements abut directly against the outer chlorophyll-bearing bundle sheath. In the larger bundles, however, the cells of the outer sheath may be smaller and only become larger at the xylem pole. In the larger bundles the cells of the inner sheath may develop at the gaps formed at the phloem pole and directly come in contact with the epidermal layers or fillers of the hypodermal cells. Towards the xylem pole a similar mass of sclerenchyma is developed, although not continuous with the inner bundle sheath.

The xylem of the larger bundles consists of two large vessels connected more or less by extensive band of small pitted elements, most of which are narrow vessels. Between these large vessels are often found the lacuna into which project the protoxylem vessels; but the lacuna may be wanting in some bundles. In the smaller bundles there are relatively few pitted vessels which border the phloem. The phloem is structurally similar to those found in the bundles of the leaf sheath.

The chlorophyll-bearing parenchyma of the mesophyll of the leaf blade form more or less concentric rings around the bundles without forming any gap of colorless parenchyma (Pl. 23, fig. 156) similar to those obtaining in the sugar cane (Artschwager, 1925).

The cells of the epidermal layers are oblong to nearly rounded in transverse section (Pl. 4, fig. 28-30) with their largest diameters in the direction of the long axis of the organ (Pl. 3, fig. 25, 27). Their cell walls are strongly undulated and suberized. In addition to the long cells there are also, as in the epidermis of the stem and leaf sheath, short cells which are nearly rectangular; these occur either singly or in pairs. The cells from the upper epidermis (Pl. 3 fig. 25) are much smaller than those in the lower epidermis (Pl. 3, fig. 27). The epidermal cells above a vein are commonly thickened and strongly silicified. These cells are more elongated, rather slender, and often thick-walled, at times hardly possessing any lumina. At the

upper epidermis there is, in addition to the two types of cells mentioned above, the so-called "hinge" or "bulliform" cells, which form longitudinal bands and alternate with the strips of epidermal cells (Pl. 19, fig. 139; Pl. 23, fig. 156; Pl. 27, fig. 176). These hinge cells are much larger than the other cells of the epidermis and differ further in that their lateral walls are thin and of cellulose. The bulliform cells undergo differentiation only after the leaf begins to unroll, when they increase in size very rapidly and become slightly depressed.

The outer walls of both epidermal layers are not smooth (Pl. 3, fig. 24; Pl. 4, fig. 28 and 30; Pl. 23, fig. 156) as numerous waxy outcrops or protuberances are found throughout. The production of these outcrops or protuberances becomes discontinuous above a vein (Pl. 4, fig. 30) where the cells are apparently thin-walled, cropping out only one short, and small rounded hump at their centers. There are, besides, the presence of long, unicellular, tapering trichomes (Pl. 3, fig. 23; Pl. 4, fig. 31) which are outgrowths of the upper epidermal cells. These hairs are absent on the lower epidermis.

At the margins of the blade (Pl. 3, fig. 23; Pl. 19, fig. 139) is present a mass of sclerenchymatous cells below the epidermal layer; these are vertically elongated and their presence is perhaps correlated with the strong non-tearing character of the blade margin of the leaf. The margin of the leaf blade as is ordinarily known is not entirely serrulate throughout. Serrations are only present from its acute apex to nearly half down. These teeth consist of stiff, long, curved outgrowths with their apices directed towards the apex of the blade and which occur at regular intervals. These are believed to consist of silica but by burning the leaf blade these marginal serrulations turn black, clearly indicating that they may be mostly lignin with only silicious incrustation.

The stomata lie on the same level with the epidermal cells (Pl. 4, fig. 28 and 29) and are found in longitudinal rows (Pl. 3, fig. 25, 27). The mature stoma is made up of distinct guard cells (Pl. 3, fig. 22) and the adjacent subsidiary guard cells. The latter become much larger than the guard cells, extending deeper radially and their outer walls slope slightly in the direction of the guard cells. The guard cells are wider at their ends than at their middle regions. The pore of the stoma is elongated, lozenge-shaped, its lateral walls being straight and parallel, or sometimes gently curved. The stomatal movements are correlated with this peculiar construction of

the guard cells. According to Artschwager (1925), Schwendener who fully investigated stomatal movements in grasses explains the opening and closing as follows: Since the middle portion of the guard cells is narrow and the tangential walls greatly thickened, any change in the osmotic pressure in the cells would be incapable of causing movement in this portion of the wall. The enlarged ends of the guard cells, however, have thin walls which will respond to turgor changes. When there is an increase in turgor, the guard cells cause the pore to open, where upon the thickened middle portions of the guard cells are passively drawn apart, leaving a slit with parallel sides.

COLEOPTILE

The coleoptile is a small envelope to the young plumule of the seedling. At its basal portion it is usually continuous (Pl. 21, fig. 145) and is traversed by two rather poorly developed vascular bundles, embedded in a ground parenchyma. The epidermal cells are radially elongated and rectangular in transverse section. As the seedling develops and the plumule emerges from the seed, the coleoptile is split apart forming a loose envelope to the elongating young plumule or shoot. Due perhaps to pressure exerted by the elongating and enlarging plumule, the inner cells of the coleoptile are pressed down (Pl. 23, fig. 157) and are consequently destroyed. However, this shoot cover eventually degenerates as the seedling grows.

INFLORESCENCE

The inflorescence of Inapostol rice is a compound raceme, or panicle, as is true with many of the rice varieties. Bhalerao (1925) believes that the inflorescence of the rice plant is of the cymose and not of a racemose type. The racemose character of the inflorescence, this author states, is only of minor importance. This inflorescence terminates the main stem of the plant. Its main axis, the rachis, bears numerous primary branches, the rachillae, on which the individual spikelets, as well as few secondary branches, if any, are borne. Before its emergence from the plant, it is usually enclosed by the sheath of the terminal leaf, the flag, and at this stage the plant is said to be booting. The individual spikelet possesses a single flower which consists of six stamens, two lodicules, a monocarpic, one-celled, unimegasporangiate pistil (Pl. 29, fig. 185), bearing an ovoid ovary, a single branched style, and two plumose, purple stigmas.

Peduncle. The peduncle is terete and exserted. Its structure is very similar to that of the internode of the stem (Pl. 1, fig. 4; Pl. 24, fig. 162). In fact it is an exact replica of the latter, except that the lacunae, or air chambers between the vascular bundles, are absent in the former.

The mature peduncle is rounded in transverse section (Pl. 1, fig. 4), limited by four to six layers of sclerenchymatous cells; the outermost layer being the epidermis, while the hypodermal layers constitute the thin cortex (Pl. 24, fig. 162). This sclerenchymatous cylinder forms a complete cover to the peduncle. Scattered below the hard cylinder are two distinct bands of vascular bundles embedded in a ground parenchyma. The outer band of bundles consists of the smaller bundles, the bundle sheaths of which come in contact with the outside sclerenchyma cylinder referred to above. These possess two large metaxylem vessels between which is a small protoxylem vessel. The phloem region is just as large as, and not appreciably larger than, one of the metaxylem vessels and possesses four to five large parenchyma with one or two small companion cells. The bundle sheaths of these bundles are well developed and usually come in contact with the outer sclerenchyma cylinder of the peduncle.

The inner band consists of the larger bundles which generally alternate with the smaller ones in the outer band. In some cases this alternate arrangement of the outer and inner bundles is lost; it is not uncommon to encounter an inner and an outer bundle occupying the same radius. The structure of these inner bundles is similar to those found in the internode of the stem. They are usually rounded to oval. Their phloem regions are well developed.

Below the outer sclerenchyma cylinder is a nearly continuous band of chloropyll-bearing cells, usually two to four layers thick, the cells thin-walled, parenchymatous and hexagonal. These chlorophyll-bearing layer is interrupted only by the presence of the smaller bundles, otherwise it forms a complete mantel below the hard cylinder. The rest of the ground parenchyma below the chlorophyll-bearing layer consists of rounded to rhomboidal or hexagonal thin-walled cells, becoming large centripetally, and these possess a large amount of starch grains. The chlorophyll-bearing cells, as well as the colorless starch-laden cells, together constitute the cells of the pith. At the central portion of the peduncle is a hole.

At the first node of the peduncle where the first primary branch or branches of the inflorescence are borne, the section is nearly solid

(Pl. 1, fig. 6; Pl. 27, fig. 177). A transverse section at this node shows the presence of an outer sclerenchyma cylinder which is composed of the epidermis and the thin cortex. The outer peripheral bundles are trapezoidal to oblong or even triangular at times, with their sclerenchyma bundle sheaths much more developed at their phloem poles where these bundles join the outer sclerenchyma cylinder. The vascular bundles forming the inner band are more crowded and close to each other than at the lower portion of the peduncle. These inner bundles, at times, form a solid group of bundles. The bundle sheaths of the crowded bundles very often fuse together. The phloem region of each bundle has been relatively increased.

The chlorophyll-bearing layer becomes correspondingly wider, and this consists of from four to six rows of cells, five rows being the most common. The one to three layers of parenchymatous cells of the pith lying between the outer and inner bands of vascular bundles are conspicuous at the nodal portion of the peduncle. The central region of the peduncle is occupied by loosely connected thin-walled cells, leaving between them large spaces. In this parenchymatous cells, as well as in those found between the bands of bundles, are stored large quantities of starch grains.

Arising from the epidermis of the peduncle are few to many, long, slender, thick-walled, unicellular trichomes. On the outer tangential walls of the epidermis of the peduncle are found numerous outcrops of siliceous incrustations, very similar to those obtaining on the surface of the leaf blade. Stomata are present.

Rachis. The rachis (Pl. 1, fig. 5; Pl. 25, fig. 169) like the peduncle, is also hollow at the internode, except at regions where the rachillae are borne. A transverse section of the internode of the rachis shows that it is somewhat oblong with very rugged, irregular surface. It is very irregular because of the presence of distinct grooves. Two distinct bands of vascular bundles are also present.

The epidermis is distinctly thick-walled and lignified. At the region where the large groove is present, a distinct cortical sclerenchymatous band is discernible, but where bulging is conspicuous the cortical sclerenchyma is hardly detectable. The bundles of the outer band are small, triangular to rhomboidal in shape, each possessing distinctly well-developed sclerenchyma cap towards its phloem pole, and this cap extends clear to the epidermis and cortical sclerenchyma. Joining the individual small bundles on their lateral inner portions is a band of sclerenchyma. Where the groove is present the outer

band of bundles becomes interrupted. Embedded between the cortex and the band of sclerenchyma joining the individual bundles are groups of two to eight layers of thin-walled chlorophyllous cells.

The large inner band of bundles occupy nearly the middle portion of the rachis. These bundles are nearly rounded to rhomboid. The phloem region, as well as the protoxylem portions, is well developed. The bundle sheath consists mainly of one to two layers of sclerenchymatous cells, much more developed at the phloem pole, where it may abut the band of sclerenchyma referred to above. These large bundles are only separated from the hole inside by few layers of parenchymatous cells but one layer is not uncommon. These bundles are not always uniform in size, as there is a tendency to have a distinctly large vascular bundle alternating with a smaller one. The cells that are found between the bundles contain chloroplasts and are usually parenchymatous, polygonal to rounded. The last two layers of cells abutting the hole inside are colorless, large, and tangentially compressed and oblong.

The smaller vascular bundles have comparatively larger phloem regions; the metaxylem vessels are present and separated by rather large amount of pitted tracheids. The protoxylem vessel is often wanting and this region is often occupied by well-developed sclerenchyma sheath.

Rachilla. The rachilla (Pl. 1, fig. 8-9; Pl. 26, fig. 170) in transverse section is somewhat triangular, possessing some four or five distinct grooves. Occupying the center of the section is a single large rounded vascular bundle, the phloem region of which is large, while its metaxylem and protoxylem vessels are not as well-developed as those found in the internode of the stem. At the bulging portions are found three to four smaller bundles, each possessing distinctly large phloem area and two metaxylem vessels between which is a number of pitted tracheids. The protoxylem vessels are generally absent. The bundle sheath of the central bundle becomes fused with the mass of sclerenchyma which occupies the region between this central bundle and peripheral smaller bundles.

The walls of the epidermis are thickened and suberized: the underlying cortical region is irregular in thickness, but its cells are also thickened and lignified. The outer walls of the epidermal cells possess a number of minute protuberances. Connecting the peripheral bundles and fusing with the epidermal and cortical sclerenchyma at the grooves is a distinct band of sclerenchyma.

The chlorenchymatous tissue occurs only at the protuberances. this being absent at the grooves. The chlorophyll-bearing tissue consists of from three to five layers of parenchymatous cells which are large and oblong to rounded.

Pedicel. In transverse section, the pedicel is nearly rounded in shape (Pl. 2, fig. 10) and has only a distinct groove. The bundles are four in number, and are nearly equal in size and shape. One of them occupies the center of the section, while the three form a peripheral band around that central bundle. The central vascular bundle is entirely surrounded by a mass of well-developed bundle sheath which entirely fuses with those of the three peripheral bundles. Each of the four bundles possesses distinct phloem region and two large metaxylem vessels, the protoxylem being indistinctly developed.

The epidermis and the cortex are composed of thick-walled cells which in their entirety form the sclerenchyma cylinder of the pedicel. Beneath this cylinder of thick-walled cells is the chlorophyllous tissue of from two to four layers of thin-walled cells.

Development of the inflorescence. Records of our last planting show that the seedlings were planted in the seed beds on June 24, 1936, transplanted on July 3, 1936; the seedlings were, therefore, 9 days old when they were transplanted. The inflorescence primordia were visible under the microscope on September 17, 1936 (Pl. 3, fig. 155). Booting was noted on October 5, 1936, and the first inflorescence emerged from the flag on October 10, 1936. It is apparent from the data given above that, under the conditions existing in our cultures, the inflorescence primordium began to differentiate or was distinctly differentiated in about 76 days from planting, and 85 days from the time the seeds were sown in the seed beds. Differentiation of the inflorescence primordium took place 18 days before the time of booting. According to Ramiah and Narasimhan (1936), the inflorescence primordium commences about 24 to 31 days before the day of emergence from the leaf or flag. These writers found that differentiation of the inflorescence took place 23 days before its emergence from the flag, the interval depending perhaps on the length of maturity of the variety. They believe that differentiation of the inflorescence from the time of transplanting is surely variable, depending on the duration of the variety, too. The importance of knowing the actual differentiation of the inflorescence in the plant can not be overemphasized because of its bearing on the time of application of fertilizers to the plant.

According to Ramiah and Narasimhan (1936), the elongation of the different parts of the shoot follows a regular sequence. If a plant has five internodes, the basal one starts its growth first, soon followed by the next above it. The next two internodes, in turn, commence their growth a week after and almost complete it by the time the topmost one and the peduncle begin to grow. The inflorescence primordium completes its growth in length a week to 10 days after the emergence of the inflorescence. During this period, the topmost internode and the peduncle proceed with their elongation, while the internodes below almost cease to grow. The process of elongation of the shoot in general continues four to five days after emergence of the tip of the inflorescence from the flag. Late inflorescences take a day or less to complete the process.

The ontogeny of the inflorescence of rice has been traced by Noguchi (1929). According to this investigator, the primordia of the primary branches are discernible as small obovate outgrowths on the floral primordium. Long before the formation of the primordia of the individual spikelets, there becomes evident on the inflorescence initial an abundant development of long, filamentous, hyaline trichomes at the bases of the lateral primary branches, the rachillae. The sequence of the development of the parts of the spikelet as reported by this author is as follows: palea inferior (lemma), upper empty glume and palea superior (palea), staminal ring and lower empty glume, stamens, pistil, and lodicules. In Inapostol rice variety, the youngest inflorescence which was obtained by the writers is shown in Plate 23, fig. 155. At this age the basal lateral branches, rachillae, are already developed (Pl. 5, fig. 36-37), and there are present an abundance of unicellular, long, hyaline hairs at their bases. Examinations of numerous young inflorescences show that the development of the rachillae is acropetal and therefore corroborates the findings of Noguchi (1929).

The development of the spikelet as herein described deviates slightly from what had been previously reported by Noguchi (1929). The young spikelet starts as a small globular swelling from the primary branches, rachillae, of the young inflorescence. Soon, the spikelet primordium cuts off a lateral ring, the lemma (Deckspelze), and this is followed very closely by the upper empty glume (Hüllspelze) (Pl. 5, fig. 38). The growing point at this stage is more or less obtuse, with its summit rounded. According to Noguchi (1929), the lemma is the first to differentiate, and this is followed simultaneously by the palea (Vorspelze) and upper empty glume. Results ob-

tained by the writers show that the upper empty glume and the lemma simultaneously appear together. The next organ to develop is the lowermost empty glume (Pl. 5, fig. 39) and this is followed by the palea, or these two organs appear at about the same time. The growing apex then undergoes rapid enlargement, and because the young palea has a rather belated or slower growth than the lemma, this palea remains as a seemingly degenerating structure between the lemma and the growing point (Pl. 5, fig. 39 and 40). At this time the staminal ring begins to appear (Pl. 5, fig. 40 and 41), and the stamens (Staublätter) only differentiate later (Pl. 5, fig. 42) as tubular structures, early forming the enlarged anthers and short filaments. The central apex of the primordium gives rise wholly to the pistil. The lodicules are the last to appear (Pl. 29, fig. 187). In the findings of the writers, therefore, the sequence of development of the organs of the spikelet of Inapostol rice variety are: lemma and upper empty glume, palea and lower empty glume, stamens, pistil, and lodicules. The apparent discrepancy in the results obtained by Noguchi (1929) and that presented by the writers may be explained, perhaps, as an expression of varietal differences, a character which may hold true only to individual varieties.

MEGASPORANGE AND EMBRYO SAC

Pistil. The pistil is one-carpelled and its ovary is one-celled. The slender style is bifurcated, each branch bearing at its terminus a plumose, amaranth purple stigma. The central primordium which gives rise to the pistil is at first rounded. Then a circular ring is formed (Pl. 5, fig. 44) at the time the anthers are about fully differentiated (Pl. 5, fig. 43). This circular ovular tissue then grows upward, one side of which growing much faster than the other. The side growing much faster forms the style and the stigmas, while the slow growing portion forms the megasporange (Pl. 5, fig. 45). If the pistil is cut longitudinally so that the megasporange is cut also longitudinally throughout its long axis, one is apt to have only one of the branches of the style (Pl. 5, fig. 46) or the style proper devoid of the stigma because the megasporange lies with its axis running half-way between the bifurcating style.

Megasporange. In Inapostol rice the writers were not able to detect the presence of more than one megasporange in the ovary. Morinaga and Fukushima (1934) found the presence the two megasporanges in an ovary of a haploid rice plant and several megasporanges with two embryo sac mother cells each. In addition, these

authors also detected few embryo sacs containing an extra synergid in addition to the normal two.

The development of the megasporange in rice has been described by Terada (1928). The megasporange begins as a V-shaped protuberance of meristematic cells from the slight curvature formed by the rudimentary ovary wall. This protuberance forms the rudimentary nucellus of the nascent megasporange. Later, the megasporange takes a lateral position due perhaps to the lateral rapid growth of the ovular tissue (Pl. 5, fig. 45 and 46). As the end of the V-shaped megasporange reaches the other opposite side of the ovary wall, the locule is formed (Pl. 5, fig. 46 and 47). The megasporange is, therefore, atropous to begin with, then it becomes campylotropous and lastly, anatropous. Soon, the inner integument develops around the base of the young nucellus (Pl. 5, fig. 45, 51). This is followed by the outer integument. The inner integument grows much faster than the outer, so that while the inner has already covered the micropylar portion of the nucellus of the megasporange, the outer integument has scarcely grown two-thirds of the way (Pl. 5, fig. 48 to 50). The outer as well as the inner integument is usually composed of two layers of cells, the latter possessing three to four layers at the micropylar end of the megasporange (Pl. 5, fig. 49 and 50). At the tetrad stage or even earlier (Pl. 5, fig. 48), the inner integument has already covered the micropyle completely.

Megaspores. Kuwada (1910) had observed that the embryo sac mother cell in rice, is formed subepidermally, and this is usually one-celled. However, this author had found the development of two embryo sac mother cells in a single megasporange, only one of which seems to be functional.

In Inapostol rice the archesporial cell differentiates long before the inner integument has had any chance to cover the nucellus of the megasporange (Pl. 5, fig. 51 and 52). This is normally one-celled, but a two-celled archesporium (Pl. 5, fig. 51) is not uncommon in this variety. The archesporial cell which functions direct as the megaspore mother cell, is more or less trapezoidal in shape and is hypodermal in origin. It is easily recognizable from the rest of the nucellar cells in that it takes stains readily and its nucleus is much larger than those of its sister cells. Even if the writers have observed two-celled archesporium, they were not able to find more than one of them forming the tetrads. Usually one degenerates and the other succeeds in forming the normal embryo sac. Terada (1928)

has reported that the archesporium of a Japanese rice, Nioiwase, is also hypodermal and trapezoidal in shape, occupying the apex of an axial row of four to five cells of the nucellus.

By the time the inner integument is about to cover the micropyle of the megasporange, the megaspore mother cell or the archesporial cell (Pl. 6, fig. 53) has undergone marked enlargement and elongation, its shape always remaining nearly trapezoidal to oblong, its wider end directly pointed towards the micropyle. Soon, it enters synapsis, and by a single division it gives rise to a dyad (Pl. 6, fig. 54). The micropylar cell is much smaller, while the inner one is more or less elongated to oblong in shape. The micropylar cell is more or less rectangular to nearly trapezoidal with its micropylar end more or less rounded. At this time the inner integument has nearly covered the micropyle, but its ends have not yet met. The epidermis of the nucellus at the synaptic stage of the embryo sac mother cell exhibits slight enlargement at its micropylar end (Pl. 6, fig. 53).

Generally, in Gramineae the archesporial cell forms no parietal tissue (Schnarf, 1929). In *Cornucopiae nocturnum* (Guignard, 1882) a primary parietal cell is formed from the first division of the archesporial cell, and this gives rise to about six layers of parietal tissue. In corn, however. the archesporial cell divides periclinally (Weatherwax, 1919), giving rise to a parietal cell and a megaspore mother cell; but no wall is formed between them, the former being immediately consumed.

The dyad does not rest long enough and the second division soon follows (Pl. 6, fig. 55), at which time the inner integument has already formed a complete cover around the micropyle. This second division gives rise to the tetrads which have very short resting period. No sooner have they been formed, than degeneration sets in among the three micropylar megaspores (Pl. 6, fig. 56), the innermost one becoming functional and giving rise to the normal embryo sac (Pl. 6, fig. 57).

Kuwada (1910) and Terada (1928) also found the development of four megaspores in a row in the rice they have examined, the innermost of which forms the embryo sac. The latter investigator made mention of the fact that the dyad may not divide at the same time, so that a triad row of cells is sometimes produced. This formation of three megaspores was not met with by the writers in the material they examined. In *Poa pratensis* and *P. compressa* four

megaspores are also formed (Anderson, 1927), usually the deepest but sometimes the outermost megaspore developing to form the embryo sac.

Embryo sac. The functional megaspore soon enlarges (Pl. 6, fig. 56), while its sister micropylar cells degenerate (Pl. 6, fig. 56 and 57). By three successive divisions of its nucleus, an eight-nucleate embryo sac is formed (Pl. 6, fig. 58 to 60). Terada (1928) and Kuwada (1910) also observed the same normal embryo sac formation in the rice they worked on. In fact in nearly all members of the grass family, the normal type of embryo sac have been reported, among which the following may be mentioned: *Zea mays* (Weatherwax, 1919), *Avena sativa, Poa annua* and *Triticum vulgare* (Golinski, 1893). In *Cornucopiae nocturnum* (Guignard, 1882), *Melica nutans, M. altissima* (Schnarf, 1929), however, a scilla-type of embryo sac has been reported, these being the only known exceptions to the rule.

The formation of the embryo sac takes place before heading time, so that at anthesis the egg apparatus is already fully differentiated, while the antipodals are undergoing degeneration and have divided themselves into a number of cells, usually not more than five. The synergids degenerate before fertilization, and their remains may persist until the zygote starts to grow, producing several cells.

The shape of the mature embryo sac is variable. The antipodals (Pl. 6, fig. 60) of the sac are the first to differentiate, and these are situated at the chalazal end. These antipodal cells may lie in a row or one above and the two others just below. To begin with, the antipodal cells are uninucleate, with their nuclei practically equal in size and shape. As the sac matures, the antipodal cells undergo nuclear divisions which are either direct or indirect. According to Kuwada (1910), direct nuclear division is more normal than indirect. This nuclear division is not usually accompanied by any wall formation, and consequently multinucleate antipodal cells are produced (Pl. 6, fig. 61 and 62). In some cases walls are formed between the daughter nuclei, and, therefore, multicellular antipodals develop (Pl. 7, fig. 63). The writers were able to count as many as five antipodal cells in Inapostol rice. According to Kuwada (1910), fourteen nuclei was the highest he was able to count in an antipodal cell, and a group of from 6 to 20 cells or sometimes much more is not uncommon. After fertilization, the antipodal cells usually undergo degeneration (Pl. 7, fig. 65), as shown by the clamping together of their contents and the degree with which they absorb the stains. In some cases, the antipodals are gone at the time of fertilization. Ku-

wada (1910) states that the antipodals disintegrate at different stages, sometimes before fertilization and sometimes after one or two layers of endosperm have been formed.

Gramineae are characterized by a great development of antipodal cells in their embryo sacs. Schnarf (1929), reviewing large number of references on this subject, stated that the number of antipodal cells ranges from three multinucleate cells of *Cornucopiae nocturnum* (Guignard, 1882) to the largest number in *Bambusa bambos*, where a complex of about 60-nucleated cell is reported.

It is of special interest to note the behavior of the antipodals in *Zea mays*. At the time of maturity of the sac the antipodal cells usually number twenty-five or more, these having arisen by the division of the original three (Weatherwax, 1926). In at least the earlier of these divisions the nuclei divide mitotically, but in later stages the division is amitotic, and cells with two, three, or more nuclei are common. After fecundation, the antipodal tissue is sometimes soon absorbed by the developing endosperm, but in many apparently anomalous cases its cells continue to divide and grow slowly at the expense of the impoverished tissue of the nucellus. Occasionally also it may prey upon the nearby cells of the endosperm. Some of its cells are filled with dense, deeply staining cytoplasm; others have large vacuoles. Cells are loosely joined together, the one or more groups resembling loosely organized colonies of some thallophytes. As many as five or six nuclei have been observed in some cells, and fragmentation of the nuclei continues until the seed is practically mature.

In *Poa pratensis* and *P. compressa* (Anderson, 1927) the antipodals are very large and persist until late in the endosperm formation, when they become vacuolated and finally disappear. Usually three and not more than five antipodals have been observed in one embryo sac, a feature similar to that reported for Inapostol rice by the writers. In sugar cane (Artschwager, Brandes and Starett, 1929) the antipodals tend to show active divisions, thus forming a mass of antipodal cells before fertilization.

The polar nuclei (Pl. 6, fig. 60) are distinctly larger than those of the nuclei of the other cells of the sac. These nuclei migrate towards the center of the sac or in its environ (Pl. 6, fig. 61 and 62; Pl. 7, fig. 63), but before fertilization these move towards the micropylar end in the vicinity of the egg apparatus (Pl. 7, fig. 64). Kuwada (1910) states that the polar nuclei migrate towards the micro-

pylar end of the sac, where they receive the male nucleus, and, although he claims that double fertilization occurs in rice, he was not able to observe actual fertilization at all.

The egg apparatus consists of two pyriform and faintly differentiated synergids, the nuclei of which are usually smaller than, if not as large as, that of the megagamete, and a megagamete (Pl. 7, fig. 63). The synergids are not persistent as was likewise observed by Kuwada (1910) and possess no filiform apparatus. The megagamete is larger, and possesses thicker cytoplasm than that of the synergids, its shape being more or less oblong.

Fertilization. Fertilization in rice is porogamous (Terada, 1928), and this usually takes place twelve hours from anthesis (Akemine, 1913). That double fertilization is a common phenomenon in rice is clearly illustrated by the microscopical material obtained by the writers and shown in Plate 7, figure 64. The pollen tube enters the embryo sac through the micropylar portion of the nucellus and passes between the two synergids. Here the tube discharges its contents, the gametes. One of the sperms is found lying just against the nucleus of the megagamete, while the other is very near the polars.

Whether parthenocarpy is a common phenomenon in rice the writers are not aware, but Morinaga and Fukushima (1935) were able to detect in autotriploid mutants in rice a seemingly parthenocarpic growth where ovaries of triploid containing normal and abnormal embryo sac had the tendency to start growth without producing proper seed parts. In a majority of those mutants, these authors further observed that the ovaries were able to enlarge so as to fill up the entire glumecavity.

MICROSPORANGE AND MICROSPORE

The stamen consists of a long, slender, white, tender filament and a large, yellowish, four-lobed, two-celled anther. Dehiscence is longitudinal and this usually takes place before or during anthesis; dehiscence may also take place after or immediately after anthesis. Eichler (1875) believes that there are two whorls of stamens in rice, three stamens in each whorl. The writers agree with Noguchi (1929) that the six stamens are all arranged in a single whorl and not in two as Eichler thought them to be.

The young anther possesses four microsporanges in transverse section, surrounded by large, thin-walled epidermal cells. A distinct

endothecium, specialized layer of cells found in anthers of many angiosperms, is absent. The anther is traversed in the connective by a single vascular bundle which is surrounded by large, hyaline, rectangular sheath cells (Pl. 9, fig. 89).

The mature anther of Inapostol rice is bilocular and dehisces either before or during anthesis; in some cases dehiscence may take place some time after. In each microsporange, which are four in number, there is developed simultaneously an archesporium which may either be one-celled (Pl. 9, fig. 78) or two-celled (Pl. 9, fig. 79) at the third layer of cells below the epidermis. The archesporial cell or cells are either trapezoidal or polygonal and are distinguished from their sister cells by the density of their cytoplasm and the size of their nuclei. These archesporial cells divide but once. If only one archesporial cell is present (Pl. 9, fig. 78), this divides twice to form the four miscrospore mother cells; if two archesporial cells are developed, a single division is needed to form the four microspore mother cells. There are cases, however, where three microspore mother cells can be found in transverse section (Pl. 9, fig. 80) and this is due, perhaps, to the fact that one of the two archesporial cells must have failed to divide.

The microspore mother cell very soon rounds off (Pl. 9, fig. 80) and its cytoplasm shrinks away from the parietal tissue; at the same time their nuclei enlarge, showing signs of the coming active division. It is triangular to oblong in transverse section (Pl. 9, fig. 80) and oblong in longtitudinal section (Pl. 9, fig. 82). It enters synapsis (Pl. 9, fig. 82) and by a single division (Pl. 9, fig. 83) it gives rise to the dyad which does not rest at all (Pl. 9, fig. 84) but right away forms the tetrads (Pl. 9, fig. 85). The division of the microspore mother cell is, therefore, successive as has also been reported by Selim (1930).

In all species of the family Gramineae so far studied, successive divisions of their microspore mother cells is the rule. This is especially true in the following species: *Zea mays* (Kuwada, 1911), *Panicum variegatum* (Suessenguth, 1919), *Phragmites communis* (Tischler, 1918), *Avena strigosa* (Winge, 1923), *Triticum* spp. Kihara, 1919), *Triticum vulgare* and *Secale cereale* (Golinski, 1893), *Paspalum mandiocanum, P. conjugatum, Triticum compactum, T. compactum,* var. *splendens, Avena sativa, Aegilops ovata* and *Bambusa bambos* (Schnarf, 1929).

The epidermis of the microsporange very early shows enlargement (Pl. 9, fig. 78, 79, 81, 83). In longitudinal section the epidermal cells are rectangular with their longer diameters parallel to the long axis of the anther. These remain parenchymatous throughout the life of the anther with their outer tangential walls rounded (Pl. 9, fig. 89).

The parietal tissue consists of two layers of cells but these may later increase to three (Pl. 9, fig. 81). These cells appear rectangular to isodiametric in longtitudinal section. The innermost layer functions as the tapetum. The tapetal cells are rectangular to squarish and very early acquire dense cytoplasm and large nuclei. These are at first uninucleate, but by the time the microspore mother cells are in anaphase stage of the heterotypic division, some of them possess two nuclei. These tapetal cells, however, degenerate and persist as a black strip surrounding the mass of microspores long before anthesis (Pl. 9, fig. 89).

The rest of the parietal tissue, which may either be one to two layers thick, are usually crushed during the development of the microsporange, so that at the time the anthers are about mature, the tapetum directly abuts the persistent epidermis to the anther (Pl. 9, fig. 89).

Young microspore. The young microspore or tetrad just at the time of separation from its sister cells is more or less rounded (Pl. 9, fig. 86), and possesses dense cytoplasm and a large rounded nucleus. Long before dehiscence the microspore acquires its two coats, the exine and intine (Pl. 9, fig. 87). The microspore possesses then a thin peripheral cytoplasm at the center of which is formed a large vacuole. The nucleus takes a usual peripheral position embedded in the thin cytoplasm. The young microspore is provided with a single germ pore where the coats seem to thicken.

Biological observation. A great deal of work has been published on the biology of the rice flower. Among them may be mentioned the works of Stok (1910), Rodrigo (1925), Thompstone (1915), Torres (1923), Sharngapani (1924), Hector (1913), Jones (1924), Laude and Stansel (1927), Poggendorff (1932), Kadam and Patil (1933), Bhide (1925), and others. A résumé of the mode of pollination in rice is presented by Pope (1916). Table 1 shows results of observations of some of the above investigators on the time of opening of the rice flowers.

TABLE 1

Time of opening of spikelets as observed by various workers.

OBSERVERS	PLACE	TIME OF OPENING OF SPIKELET
Hector (1913)	Dacca, India	7–8 a. m., continuing till about 10 a. m. for *Aus*, and 9–10 a. m. continuing till midday for *Aman*
Rodrigo (1925)	Agricultural College, Laguna, Philippines	9–11 a. m., very infrequently between 6:25–9:00 a. m., and between 11:30–12:30 p. m.
Laude and Stansel (1927)	Beaumont, Texas, U. S. A.	8 a. m. to 4 p. m., majority opening at 10 a. m. to noon.
Poggendorf (1932)	Yanca, New South Wales	8–9 a. m., reaching maximum between 11:30–12:30 p. m., ceasing between 3–4 p. m.; may occur as early as 6 a. m. with maximum period between 9–10 a. m., and as late as 5:30 p. m.
Kadam and Patil (1933)	Karjat, India	9 a. m. to noon; after noon there is a rapid fall, and ceases after 2 p. m.
Bhide (1925)	Karjat, India	Begins at 10 a. m., vigorous between 10:30 to 11 a. m., continuing till 11:30 or noon.
Thompstone (1915)	Upper Burma, India	Begins at 7 a. m., maximum at 8–9 a. m., and ceases at 10 a. m.
Thompstone (1915)	Buitenzorg, Java	Begins at 6 a. m., maximum from 10–12 noon, ceasing at 3 p. m.
Stok (1910)	Java	10–12 noon, some may be open 9–10 a. m., and between 12 to 1 p. m.
Sharngapani (1924)	India	For *Aus* planted July–August, open at 7 a. m.; for *Sail* planted October, open at 9 a. m.
Jones (1924)	California, U. S. A.	Begins at 10 a. m., maximum at 12 noon to 2 p. m., ceasing at 5 p. m.
Adair (1934)	Arkansas, U. S. A.	Begins before 9 a. m. to 4 p. m., none opening before 8 a. m. and after 4 p. m.; maximum at 10 a. m. to 12 noon.
Torres (1923)	Alabang, Rizal, Philippines	Opens between 9–11:30 a. m.
Juliano and Aldama	Agricultural College, Laguna, Philippines	Opening between 9 a. m. to a little past 11:00 a. m.

Results of observation of the writers on the time of opening of the spikelets of Inapostol rice variety on two bright sunny and two cloudy days during the month of October, 1936, gave results which are in agreement with those reported by Rodrigo (1925) and Torres (1923). During cloudy and rainy days opening may begin at 10:00 a. m. and completely ceases at 11:00 a. m.; in some cases opening may be delayed as late as 1 to 2 p. m. The maximum number of dehiscing spikelets was observed to take place at 10:35 a. m.

Rodrigo (1925) reports that on the average it takes the spikelet about 6 to 7 minutes before the glumes are fully extended. Laude and Stansel (1927) in Texas found that a single floret requires 1 to 3 minutes to open. Poggendorff (1932) states that the flower requires about 60 to 180 seconds to open, while Copeland (1924) specified 30 seconds. Observations of the writers on Inapostol rice show that on bright sunny days the spikelet requires on the average 4 minutes and 24 seconds to open, while on cloudy and windy days it needs on the average 3 minutes and 20 seconds. Hector (1913) says about 15 minutes elapse from the opening of the glumes to the time the anthers assume the pendant position. Früwirth in 1909 as cited by Pope (1916) observed the following interesting sequence: flower began to open at 14 minutes after 10 o'clock in the morning; it was fully opened at 14 minutes, 30 seconds past 10; the anthers burst at 10:21; and the flower closed at 1:00 p. m. In Java Stok (1910) found that the flowers remain open from two to two and half hours, and, if pollination is delayed, four hours or even longer. The flowers opening early in the day remain open longer than those blooming toward midday. It seems, therefore, that when weather is favorable the spikelets take some time to open; this is perhaps due to the fact that the angle of divergence of the lemma and palea is greater during clear weather, while this is much less on cloudy and windy days. On rainy days the spikelets very often do not open at all, and pollination is autogamous.

The duration of time that the spikelets of Inapostol rice remains open is practically the same on clear days as on cloudy windy days. On the average they remain open for a period of 33 minutes on cloudy windy days and 32.5 minutes on clear sunny days. Rodrigo (1925) reports that on the average, the flowers of Binicol, Inintiw and Binambang remain open from 48 to 55 minutes. In Texas (Laude and Stansel, 1927) and in New South Wales (Poggendorff, 1932), the floret remains open from 40 to 120 minutes, and 13 to 75 minutes, respectively. It is probable that the length of time that the spikelets re-

main open greatly depends on the relative humidity of the air; the time is shorter at low humidity and longer at high humidity.

The writers observed that the number of the spikelets to a panicle in Inapostol rice varies from 64 to 91. All of them are open after an average of two to five days. Hector (1913) reports that in India it takes ordinarily 4 days for all the spikelets in a panicle to open; in Texas (Laude and Stansel, 1927), 5 to 9 days; in Kolamba rice of India (Kadam and Patil, 1935), 5 to 6 days.

Akemine (1913) summarizes his results in Japan as follows: Rice under unfavorable conditions sometimes forms cleistogamous flowers. The glumes normally open at an angle of thirty degrees. The opening is brought about by the swelling of the lodicules to three times its former thickness. The only change in the pistil is the lateral expansion of the style. Pollination takes place either immediately before or at the moment of opening of the flower. Under unfavorable conditions, fertilization commences about 12 hours after flowering and is complete about one day. The opening of the glumes offers no absolute physiological advantage, since the fruits can form equally well when the flowers remain closed. Cross-fertilization often occurs in rice if the anthers do not assume their natural position, either on account of incomplete development or unfavorable environmental conditions.

Blooming proceeds from the top of the panicle downward and from the free ends of the panicle branch to its base. A similar observation has also been reported by Pope (1916) who belives that the immediate causes of dehiscence are probably the pressure of the anther on the glumes caused by the elongation of the filaments, the sudden shock caused by the opening of the glumes, and the access of air and sunlight.

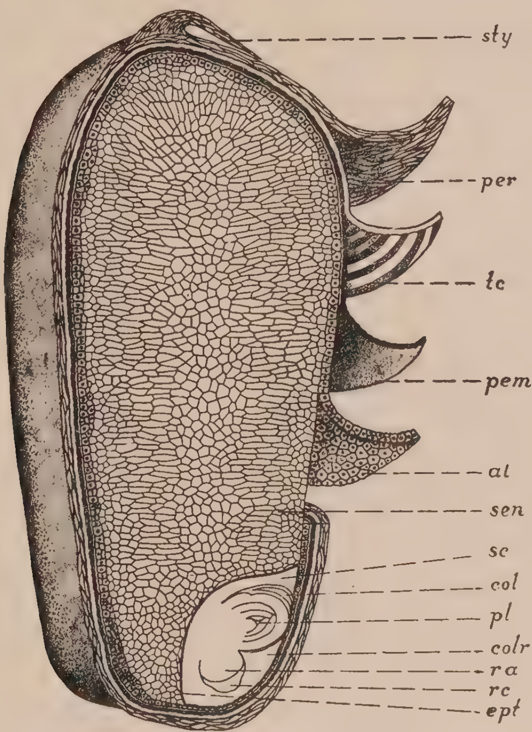
THE FRUIT

The hull and accessory parts

The mature fruit of Inapostol rice with its hull intact is more or less oblong. It varies from 8.42 to 8.57 centimeters in length, from 2.69 to 2.51 millimeters in width, and from 1.75 to 1.82 millimeters in thickness. The hull (lemma and palea) is somewhat yellowish to straw-colored, with the glumes shiny and likewise straw-colored.

The caryopsis devoid of its hull is more or less oblong, translu-scent, white and non-glutinous. This measures on the average 6.31

millimeters in length, 2.30 millimeters in breadth, and 1.64 millimeters in thickness. At its basal portion and lying to one side is located the embryo in an opaque depression. The greater part of the caryopsis is occupied by the starchy endosperm (Pl. 10, fig. 90). This caryopsis is more or less oblong-obovate and in transverse sec-



Textfig. 1.—Reconstructed diagram of a longitudinal section of a mature caryopsis showing parts, particularly the bran layers; *al*, aleurone layer; *col*, coleoptile; *colr*, coleorhiza; *ept*, epithelium; *pem* perisperm with adhering coat; *per*, part of pericarp; *pl*, plumule; *ra*, radicle; *rc*, root cap; *sc*, scutellum; *sen*, starchy endosperm; *sty*, remains of style; *tc*, tube cells as innermost cells of pericarp. × 23.

tion it is rounded to somewhat oblong. The outer surface is somewhat glabrous and dull brownish in color, possessing two distinct longitudinal ridges on the flattened surfaces.

Empty glumes. The lower and upper empty glumes are similar in size and shape, and these measure about 1.65 millimeters long. They

are nearly triangular to linear-lanceolate, somewhat flattened to a bit concave. The concave sides are directed towards the axis of the spikelet. At flowering time the glumes are pale green, more or less shiny, glabrous, finely serrulate at margins; but at maturity their color changes to straw or ivory white and they become brittle and hard.

A transverse section of a young empty glume from a spikelet prior to emergence from the flag or last leaf (Pl. 21, fig. 148) shows a single vascular bundle which is poorly developed, and this is embedded in a thin ground parenchyma. The bundle is situated at its thickest central portion, from where the glume thins out towards its margins (Pl. 22, fig. 153). The mesophyll or ground parenchyma consists of rounded, thick- to thin-walled cells which are vertically elongated (Pl. 26, fig. 173). These cells may be only one layer thick at the margins, but seven or more layers at the thickest portion of the glume where the single vascular bundle is located. The inner epidermal cells (morphologically the upper epidermis) are much larger than those found on the opposite side.

At maturity of the glume the cells become heavily lignified (Pl. 15, fig. 118), thus rendering it hard to cut with the rotary microtome. The epidermal cells become thick-walled and their lateral walls are somewhat wavy (Pl. 15, fig. 116 and 117). In the central portion of the glume two kinds of parenchyma cells are present (Pl. 15, fig. 115). Some are elongated with thick walls and provided with minute lateral protuberances, while others are short with comparatively thinner walls. The writers were able to detect the presence of parenchyma with fairly distinct teeth or protuberances on one or on both sides. These cells are, however, very small and range from 90 to 187 microns in length.

Stomata are found scattered on the outer epidermis of the glumes (Pl. 15, fig. 117).

Lemma (*palea inferior*). This is the third flowering glume to the spikelet. When young and immature, it is usually pale green with crosswise intersecting rows of small tubercles, and possessing few to many outgrowths or hairs towards its upper portion or shoulders near its apex. It is boat-shaped and is traversed by five distinct but poorly developed vascular bundles. At maturity it becomes nearly straw-colored, highly silicified, tough to brittle, with its hairs per-

sistent and bristle-like. It usually measures about 7 millimeters long and 2 millimeters or less in width.

In transverse section the lemma is nearly V-shaped with its margins curved inward where it clasps the palea (palea superior) very snugly (Pl. 28, fig. 181). It is not so very uniform in thickness as is reported by Santos (1933) ; it is usually thicker at the median portion, whence it thins out to the basal and apical regions.

When young the lemma is surrounded by large epidermal cells nearly throughout (Pl. 28, fig. 181), except at regions where it comes in contact with the palea. At the time the spikelet is still small and long before it emerges from the body of the plant, the basal portion of the lemma possesses radially elongated inner epidermal cells with their outer tangential walls concave (Pl. 11, fig. 93). The outer epidermis is small and rectangular with the outer tangential walls nearly flattened. The hypodermal cells consist of an inner layer of rectangular to squarish cells which are elongated transversely. Between this inner layer of cells and the outer epidermis are three to four layers of thin-walled parenchymatous cells which are elongated vertically. These four to five hypodermal layers of cells may increase in number at the thicker portion of the lemma (Pl. 11, fig. 95), especially those rectangular cells lying below the inner epidermis.

In transverse section the outer epidermal cells exhibit uneven growth on their outer tangential walls as the lemma matures (Pl. 14, fig. 98) forming distinct ridges responsible for the production of series of rows of small tubercles. On the depressions are found small globular trichomes.

The outer epidermis (morphologically the lower) consists of large cells with their outer tangential walls irregularly undulated which give them a jagged, comb-shaped appearance (Pl. 4, fig. 32). These epidermal cells are rectangular, with their long diameters parallel to the circumference of the spikelet. The cytoplasm in each cell is rather thin, wherein the single nucleus is embedded; this nucleus is usually situated at the depression (Pl. 12, fig. 97 and 98). The inner epidermal cells are also large, thin-walled, and rectangular with their long diameters more or less radial to the lemma. Their outer tangential, as well as radial, walls are more or less flat. In surface section these are distinctly oblong to elongate (Pl. 12, fig. 100). These inner epidermal cells become tangentially shorter where the palea touches the lemma and the lodicules. This is mainly due,

perhaps, to compression, although their lateral radial walls do not show any such effect. The outer epidermal cells at the edges of the palea where they curve inward are also small.

The cells between the two epidermal layers are rather small, more or less polygonal, ranging from three to four layers at regions where the vascular bundles are absent, increasing at the edges or margins to six layers or more. At the lower half of the palea these layers may increase to six where the bundles are absent and much more so where the bundles are located.

The vascular bundles are poorly developed (Pl. 12, fig. 98), possessing relatively few phloem and xylem elements which are surrounded by a single layer of thin-walled bundle sheath cells.

At maturity of the grain lignification of the cells of the lemma takes place. The irregular undulating tangential walls of the outer epidermal cells become highly thickened and silicified (Pl. 10, fig. 91; Pl. 11, fig. 94 and 95; Pl. 13, fig. 102). In surface view the outer epidermal cells show a very characteristic shape and these are arranged in axial rows, with unicellular, simple, thick-walled hairs irregularly distributed. The cells are more or less rectangular, with their lateral walls highly wavy or toothed (Pl. 4, fig. 35) and thickened so that the adjacent cells snugly fit together at these undulation. These sharp undulations or teeth interlock with the neighboring cells. In fact, the outer epidermal cells of the lemma are identical with those found in the palea (Pl. 4, fig. 33).

The mature lemma in transverse section (Pl. 13, fig. 102) shows the presence of distinct siliceous incrusted ridges on the outer, heavily lignified tangential walls of the outer epidermal cells. The epidermal cells are large, with their lumina at the center, and these are located at the depressions between the incrusted ridges of silica. The flanges are thick-walled, hardly possessing lumina, and these represent the teeth or lateral protuberances so conspicuous in surface section (Pl. 4, fig. 35). Below this outer epidermis are two distinct layers of hypodermal sclerenchymatous cells; in some places a third layer is distinguishable. The rest of the cells below are composed of crushed parenchyma, the identity of which can only be determined from surface view. In longitudinal section (Pl. 10, fig. 91) the outer epidermal cells are represented by their lateral protuberances or teeth and these appear to be palisaded cells, having very small lumina. The hairs snugly fit between these palisaded cells. The walls are distinctly lamellated and pitted. The two hypodermal

sclerenchymatous layers consist of longitudinally elongated cells. Below these two layers of sclerenchyma are the crushed parenchyma.

The hairs or trichomes have thin walls when young, but, as they mature, their walls become highly thickened and silicified. These hairs originate from the outer epidermal cells which never undergo marked enlargement and change in shape so peculiar to the rest of the outer epidermal cells. The epidermal cells giving rise to the hairs fit tightly between the teeth of the enlarged epidermal cells (Pl. 11, fig. 95).

The inner epidermis, the cells of which are enlarged when young, become destroyed by pressure during the subsequent development of the caryopsis within. This layer of epidermal cells was called epithelium by Santos (1933), who states that they are remarkably large, thin-walled, hyaline empty cells rendered inconspicuous at maturity of the grain. This investigator also reports the presence of stomata on the epithelial cells; the former, according to him, are composed of bean-shaped guard cells surrounded by large subsidiary cells. The writers were able to detect the presence of small cells among the inner epidermal cells of the lemma in transverse section, and these are, perhaps, the stomata referred to by Santos.

Beneath the outer epidermal cells of the lemma are found two to three layers of lignified sclerenchymatous cells. These hypodermal cells exhibit outgrowths or teeth on one or two sides. These teeth are adjusted with the pits or corrugations of the epidermal cell walls. Haberlandt (1914) cites Von Höhnel's work of 1875, which described a unique and exceedingly effective mode of attachment of the epidermis to the hypodermal layer as occurring in the paleae of *Oryza sativa;* this consists of two kinds, one with one row of teeth and the other with two rows. The interior sclerenchyma do not, however, have these teeth or protuberances and are strictly smooth. The inner region of the lemma is occupied by two to several layers of tangentially elongated, slightly pitted, compressed parenchyma.

The inner surface of the mature lemma shows the presence of long, rectangular to elliptical cells between which may be found one or two small cells, and their walls are thickened and slightly wavy (Pl. 4, fig. 34). These cells do not, however, represent the epithelium referred to above, but are the remnants of the compressed parenchyma lying below the two to three layers of hypodermal sclerenchyma mentioned above.

Macerated material of the mature lemma shows a very interesting variety of cell shapes. The results given by Santos (1933) are

herein confirmed wholly or in part. The sclerenchyma are of two types; one of them has either one row of teeth similar to that shown in Plate 14, figure 108, or two rows of outgrowths or teeth (Pl. 14, fig. 111, 113), and the other, with simply plane sclerenchyma devoid of outgrowths (Pl. 14, fig. 113). The parenchyma are of two types also; one is elongated with rather thick walls and wavy outline, while the other is short and thin-walled (Pl. 14, fig. 112, 114). Trichomes of varying lengths are found in fragmentary forms in the macerated material similar to that shown in Plate 14, figure 106.

An individual macerated cell from the outer epidermis (Pl. 14, fig. 109) is devoid of silica impregnation. In addition we find fragments of the caryopsis which adhere to the lemma and these show the presence of degenerated cells of the pericarp (Pl. 13, fig. 104) and distinct pentagonal cells from the aleurone layer. The vessels in the bundle show spiral thickenings (Pl. 13, fig. 105) surrounded by hexagonal, oblong parenchyma.

Palea (palea superior). This is the next glume to the lemma. It is usually much smaller than the lemma, but is generally similar in structure, shape and texture (Pl. 28, fig. 181). Three vascular bundles traverse the palea. Attached to the lower portion of the palea at its two margins are the two lodicules (Pl. 29, fig. 185). These lodicules possess poorly developed vascular bundles and "fuse" with the palea as found by Schuster (1910), Weatherwax (1929) and Santos (1933).

In transverse section the young palea is practically similar to the lemma. The outer epidermal cells are irregularly undulated and large (Pl. 11, fig. 97), possessing also thin cytoplasm in which a single nucleus, usually located at the indentation, is embedded. The epidermal cells become conspicuously smaller at portions where the palea becomes adpressed to the clasping margins of the lemma (Pl. 28, fig. 181). The inner epidermis is also similar to that found in the lemma, but here its cells become conspicuously small just beyond the points where the lemma and palea are clasping one another. A much less dwarfing of these inner epidermal cells takes place at the upper half just interior to the median vascular bundle where the cells tend to become squarish. Attached to the inner epidermal cells are also globular trichomes.

The cells lying between the two epidermal layers are polygonal to hexagonal in transverse section and are vertically elongated. They vary from five to six layers in thickness at the middle and less at the upper and lower half of the palea.

Traversing the palea are three vascular bundles, two of them are found near its margins and these are much smaller and less developed than that situated at the middle. The large bundle shows faintly larger and stronger development of its phloem and xylem elements than the other two bundles (Pl. 11, fig. 97).

At maturity of the palea, the large inner epidermal cells at its lateral portions become obliterated as the caryopsis matures. The outer epidermal cells, on the other hand, exhibit similar lignification and silicification as those found in the lemma. The hypodermal cells become also highly thickened and lignified.

The outer epidermal cells of the young palea are rectangular in surface view with their lateral walls exhibiting heavy indentations or teeth, which snugly fit together with those of the neighboring cells similar to that shown in Plate 4, fig. 32. The walls are rather thick. The absence of small cells is very conspicuous. At maturity these epidermal cells exhibit practically the same structural changes found in those of the lemma (Pl. 14, fig. 110), although the cells of the former seem to be much smaller (Pl. 4, fig. 33) compared with those of the latter (Pl. 4, fig. 35). The cells found on the inner surface of the mature palea are distinctly rectangular to elliptic, triangular to oblong on surface view, with walls thick and wavy (Pl. 29, fig. 186).

Macerated preparations from the mature palea show cell elements much identical to those found in the lemma. Sclerenchyma with two rows of teeth (Pl. 14, fig. 108c, 111) or only one row (Pl. 14, fig. 108a) are also encountered. Plane sclerenchyma (Pl. 14, fig. 108b) are not uncommon. Small, thin, wavy-walled parenchyma of various shapes and sizes are also present (Pl. 14, fig. 107) and together with these are also sparingly detectable fragments of the trichomes (Pl. 14, fig. 106).

Awn. This is a prolongation of the apiculus of the lemma, being found in majority of bearded varieties of rice from the northern provinces. In Inapostol rice the awn is invariably developed in some of the terminal grains on a panicle. This is somewhat straw in color, long to short, terete and glabrous. It usually measures from 1.0 millimeter to 12.6 millimeters in length and approximately 0.3 millimeter in diameter.

In transverse section the mature awn is rounded. The epidermal cells are more or less rounded, thick-walled and lignified. On the outer tangential walls of the epidermal cells is found a heavy, thick coating of cuticle. The cells below the epidermis exhibit also

high degree of thickenings and lignification on their walls, and these may range from six to seven layers thick (Pl. 13, fig. 103). These hypodermal sclerenchymatous cells together with the epidermis form in their entirety a solid sclerenchyma cylinder to the awn. Enclosed by the sclerenchyma cylinder is a mass of rounded, loosely arranged parenchyma wherein is embedded the single central vascular bundle to the awn. This bundle possesses few xylem and phloem elements enclosed by a poorly developed bundle sheath.

Surface section of the mature awn (Pl. 15, fig. 119) shows the presence of long, slender cells with their end walls obliquely or horizontally set. These cells, however, seem to be thin-walled at low magnification but are really thick-walled. Their walls are somewhat straight. These epidermal cells may be short or long, rectangular to trapezoidal.

Macerated material of the mature awn shows the presence of long, spindle-shaped sclerenchyma with walls plane (Pl. 15, fig. 122) and also plane parenchyma with comparatively thinner walls. Among them may be found rectangular to oblong, thin-walled cells with their end walls rounded to oblong (Pl. 15, fig. 121). Besides, short sclerenchyma with sharp tapering ends, as well as sharp thick-walled trichomes, are also present (Pl. 15, fig. 120).

Rudimentary glumes. These are the distinct swellings lying along the axis of the spikelet and between the empty glumes and the palea and lemma (Pl. 29, fig. 189). These structures have been pointed out by Bernegg (1929). Maceration of these rudimentary glumes show the presence of sclerenchyma of various shapes and sizes (Pl. 29, fig. 183). Some are oblong to rounded, while others are extremely elongated. There are also present sclerenchyma with plane walls, and others with wavy and irregularly toothed walls.

Parts of the caryopsis

Endosperm. That the endosperm of Gramineae is of the nuclear type (Schnarf, 1929) is well known. Of those species so far investigated, *Zea mays* (Guignard, 1901), *Eleusine caracana* (Guérin, 1899), *Triticum vulgare* and *Secale cereale* (Golinski, 1893), *Poa pratense* and *P. compressa* (Anderson, 1927), and *Saccharum officinarum* (Artschwager, Brandes and Starrett, 1929) show also nuclear type of endosperm. Soon after fertilization, the primary endosperm nucleus undergoes rapid divisions, during which time a large central vacuole in the embryo sac is formed. This forces the free endosperm nuclei to migrate towards the walls of the sac or

against the impoverished nucellus (Pl. 7, fig. 68). Soon walls are formed around these free peripheral endosperm nuclei (Pl. 7, fig. 69) and the nuclei of these initial endosperm cells undergo further divisions. Cell divisions proceed until the whole sac becomes completely filled up with endosperm tissue. The initial endosperm cells form the aleurone layer (Pl. 7, fig. 69 and 70; Pl. 8, fig. 71 and 72; Pl. 10, fig. 92; Pl. 12, fig. 99) in the mature caryopsis. This aleurone layer is usually composed of a single row of cells which are polygonal to rectangular and are densely filled with cytoplasm (Pl. 8, fig. 71; Pl. 10, fig. 92). In certain regions this aleurone layer may consist of two (Pl. 8, fig. 72) to as many as five layers of cells. Haberlandt (1914) states that typically the aleurone layer is only one cell thick, but in *Oryza sativa, Arrhenatherum elatum* and certain other species, it becomes two-layered and in *Hordeum* even three- to four-layered, owing to tangential division.

Kuwada (1910) observed a similar development of endosperm in his rice material from Japan. This author states that in later stages of division this is sometimes not accompanied by wall formation so that binucleate endosperm cells are formed. These nuclei finally fuse, however, and make a syntriploid nucleus. This investigator was only able to observe one mitotic figure of these double nuclei in which the spindles were fairly visible. The writers did not observe similar divisions in the endosperm cells of Inapostol rice.

Seed coats. Santos (1933) states that during the development of the grain the outer integument is absorbed and that at the same time the outer integument is about completely destroyed, the inner integument consists of only two layers of rectangular cells of unequal size. Ishikawa and Shibuya (1930) find that the seed coats of the fertilized grain in rice are derived from the inner integument consisting of two layers of cells in the first stage. The outer layer begins to degenerate soon after fertilization and entirely disappears about five days later. They believe, therefore, that the seed coats of the mature grain consist of only the inner cell layer of the inner integument.

In the common rice (Ishikawa and Shibuya, 1930) this inner layer of the inner integument gradually loses its vitality and activity, and degenerates, being finally reduced to a thin layer. In red rice, however, these investigators report that this layer increases in thickness, followed by an accumulation of the pigments. These pigments appear about three to four days after fertilization, and in general

increases in amount about two weeks after fertilization. The layer decreases in thickness gradually from five to nine microns about three weeks later.

Guérin (1899) observes that of the two integuments covering the megasporange of rice, each of which consists of only two layers of cells, the inner integument is the more developed, persisting for some time. However, at maturity the integuments become represented by a band of cells, the identity of which could not be determined.

According to Terada (1928), the integument of the rice megasporange he has examined in Japan possesses three to five rows of cells. The outer integument has two rows, while the inner has three rows. The inserted cell layers of the inner integument collapse into thinner cell layers, generally observable after heading time. The outer integument degenerates soon after anthesis, and a few days later the cells are disorganized. Other layers of the inner integument are hardly recognizable owing to pressure; they form a very thin layer about eight days after anthesis. The two cell layers between the tubular cells and the aleurone layer are derived from the inner layer of the inner integument and the epidermis of the nucellus.

In Inapostol rice the outer and inner integuments of the young megasporange also consist of two layers of cells each. The inner integument, however, after growing for some time, acquires more layers of cells at its micropylar portion, especially conspicuous at the tetrad stage (Pl. 5, fig. 49), when the integument has completely enveloped the nucellus. The outer integument, on the other hand, has a very limited growth compared with the inner (Pl. 5, fig. 49-50) and hardly reaches the summit of the nucellus.

The outer integument shows signs of degeneration first. At the time the zygote is three-celled (Pl. 7, fig. 67), the outer integument seems to possess in longitudinal section much larger cells, although their cytoplasm is much thinner and their nuclei much smaller compared with those found in the inner integumental cells. At the time the free endosperm nuclei have formed a thin layer against the degenerating nucellar tissue (Pl. 7, fig. 68), the outer integument is entirely absent.

The inner integument, which consists of two layers of cells, is the more persistent of the two integuments of the megasporange. At the time the cells of the outer integument are very much enlarged (Pl. 7, fig. 67), the inner integumental cells are quite elongated, rectangular, with their long axes nearly five times their breadth. When

the outer integument has entirely disappeared (Pl. 7, fig. 68), the inner integumental cells remain unchanged; but at the moment the first layer of endosperm cells are laid out and their nuclei are exhibiting active divisions (Pl. 7, fig. 69), the outermost layer of the inner integument has disappeared (Pl. 7, fig. 70). The innermost layer of cells, however, persists for a long while in the young developing caryopsis (Pl. 8, fig. 71 and 72) and the cells may be rectangular at first, then oblong to obovate later, with their end walls straight in longitudinal section. These persistent cells of the inner integument abut directly the nucellus where their walls are rather thick. At maturity of the caryopsis this persistent inner epidermis of the inner integument becomes obliterated and collapses (Pl. 10, fig. 92; Pl. 12, fig. 99). True (1893) observes practically the same development of the seed coats in corn, wheat and oats, where the inner integument becomes soldered to the adjacent inner cells of the pericarp forming the fruit.

In sugar cane (Artschwager, Brandes and Starrett, 1929) the seed coats consist of fused pericarp and inner integument. The pericarp is made up of several layers of cells, of which only the outer and inner epidermal layers are distinguishable. The outer epidermis is slightly undulated and consists of large rectilinear cells with relatively thin walls. The inner epidermal cells consists of thin-walled tubular cells which lie parallel to the outer epidermal cells running from base to apex. They are circular or broadly elliptical in cross section. The inner integument forms a single layer of cells, larger than the pericarp.

The divergent results obtained by the different investigators mentioned above compared with those reported by the writers may be due to two principal causes. Firstly, that may be due to the difference in degree of maturity of the grains examined, and, secondly, that that character and behavior of the inner integumnt in the different types of rice examined are certainly peculiar to them and genetically constant. If the second cause is true, then the possibility of identifying different rice varieties becomes obvious.

Nucellus. The nucellus of the megasporange of Inapostol rice is rather scanty (Pl. 5, fig. 51 and 52), especially up to the time of fertilization. However, after fertilization the megasporange, as well as the young caryopsis as a whole, undergoes very rapid enlargement, and consequently the nucellar tissue correspondingly increases in bulk. At the time the zygote is three-celled (Pl. 7, fig. 67), the nucellus consists of rectangular to elongated, large parenchyma which

are delimited on the outside by more or less squarish cells of its outer epidermis. When the free endosperm nuclei are found against the wall of the sac (Pl. 7, fig. 68), the nucellar tissue is reduced to a few large, degenerating hypodermal cells and a distinct rectangular, though much smaller, epidermal cells. This situation becomes much more conspicuous (Pl. 7, fig. 69) when the first layer of endosperm cells are formed and when destruction of the hypodermal nucellar cells have reached its maximum. By the time the endosperm becomes cellular (Pl. 7, fig. 70), nothing remains of the nucellus except its outer epidermis, and a few degenerating nuclei and remains of the walls of its hypodermal cells. Ultimately, the endosperm lies directly against the more persistent outer epidermis of the nucellus as the caryopsis is nearing maturity (Pl. 8, fig. 71 and 72). These persistent nucellar cells also degenerate later, and only form a thin layer which constitutes the perisperm to the mature caryopsis (Pl. 10, fig. 92; Pl. 12, fig. 99). The seed coat arising from the inner epidermis of the inner integument becomes incorporated in this perisperm of the caryopsis.

Santos (1933) describes the perisperm cells as tangentially elongated or rectangular cells with dense cytoplasm. In longitudinal section they are either irregularly shaped, rounded or tangentially elongated with small intercellular spaces and contain small amount of cytoplasm. In longitudinal section they are usually axially elongated or rectangular in outline with slightly wavy walls. The writers found that the perisperm cells are only visible before complete maturity of the caryopsis. In corn, wheat and oat (True, 1893) the epidermis of the nucellus also persists, though much compressed.

Pericarp. The ovary wall at the time the tetrads are formed, consists of two epidermal layers (Pl. 8, fig. 73) enclosing rather fairly good number of hypodermal cell layers. The outer epidermal cells are rectangular in transverse section; the inner epidermal cells are much elongated and compressed so that their lengths are about five or even six times their breadth. Between the two layers of epidermal cells are found large isodiametric, thin-walled cells through which three vascular bundles traverse the ovary. One of the vascular bundles (Pl. 5, fig. 48) is found just at the attachment of the megasporange, while the other two are on the two lateral sides. The cells between the epidermal layers are larger towards the outer epidermis, but they become smaller inward. There are about eight or nine such layers of cells.

When the zygote is three-celled (Pl. 7, fig. 67), the pericarp consists practically of the same number of cell layers. The outer epidermal cells are rectangular with their long diameters parallel to the circumference of the ovary wall. The innermost epidermal cells are elongated and rectangular; these cells and the first layer below it have the same shape. This situation indicates very clearly that they are undergoing great compression resulting from the increase in size of the megasporange within. The rest of the hypodermal cells are more or less squarish to rectangular, with thin cytoplasm and rather large nuclei.

The pericarp cells are small when the caryopsis is young, but as enlargement follows, the pericarp cells also undergo rapid enlargement (Pl. 7, fig. 67, 70). The innermost layer, as well as those above this, become compressed and elongated (Pl. 7, fig. 67). Those above these elongated cells towards the outer epidermis become filled up with chloroplasts especially at the time the caryopsis is at the "dough" stage (Pl. 7, fig. 68). This situation becomes more apparent as the caryopsis reaches maturity (Pl. 8, fig. 72), when the pericarp cells become stretched and assume various shapes. The outer epidermal cells remain rectangular, with their long diameters parallel to the length of the caryopsis.

The innermost cells and those lying above them become tubular, owing perhaps to compression and rapid elongation, attaining nearly more than twenty times their diameters. Haan (1911) and Santos (1933) observed only a single layer of such tubular cells in the mature caryopsis. However, in earlier stage in the development of the pericarp, two or even three layers of such tubular cells are often distinctly formed, but as the caryopsis matures, the hypodermal tubular cell layers disappear and only the innermost one persists. These tubular cells are not easy to demonstrate in either longitudinal or transverse section of the mature caryopsis as they are ultimately pressed down by the seed within. In surface sections, however, these tubular cells are easily seen (Pl. 12, fig. 101). Tubular cells derived from the inner epidermis of the ovary wall in sugar cane, lying parallel to the outer epidermal cells and running from base to apex, have also been reported by Artschwager, Brandes and Starrett (1929).

At complete maturity of the caryopsis, all the pericarp cells become greatly stretched, obliterated, and collapsed; nothing remains

except their compressed walls (Pl. 10, fig. 90; Pl. 12, fig. 99). In wheat, however, the pericarp is not much obliterated at maturity of the grain (True, 1893). Guérin (1899) states that in developing rice grain the pericarp cells tangentially elongate and become compressed so that it consists of only six to twelve layers of cells. The writers were not able to actually distinguish the identity of the individual cells of the pericarp at the time the grains are fully mature and dry. In corn and oat (True, 1893) as well as in *Poa* (Anderson, 1927) the cells of the ovary wall are also compressed to a thin layer and in varying proportions, forming the pericarp.

It is interesting to note that similar sections made from the local rice variety, Pirurutung, reveal the presence of distinct pericarp cells which contrast with the collapsed ones reported by the writers in Inapostol rice. In this connection it is, perhaps, possible to separate varieties on the basis of their pericarp cells.

Embryo. The development of the zygote does not proceed soon after fertilization (Pl. 7, fig. 66). However, at the time the endosperm free nuclei lie embedded in a thin peripheral cytoplasm in the sac, the zygote is already two-celled (Pl. 8, fig. 74). Plate 8, figure 75 shows the four-celled proembryo. Irregular divisions seem to proceed from this time on and, before the endosperm becomes cellular, the proembryo has attained a fairly large size (Pl. 8, fig. 76).

By the time the embryo becomes fully differentiated, it possesses distinct, although rather few suspensor cells (Pl. 8, fig. 77), which are greatly enlarged and contain a dense cytoplasm and fairly large nuclei. At this time the endosperm is completely cellular, filling practically the whole sac. The scutellum of the embryo possesses distinctly palisaded epithelial cells (Pl. 9, fig. 88).

RICE BRAN

In the preparation of the unhulled rice (palay) for human consumption, the glumes as well as the hull (lemma and palea, and awn, if present) and the colored outer portion of the rice grain or kernel are removed partially or completely with the us of either the native wooden mortar and pestle and native "guiliñgan" or both, or the modern mill. In order to give the rice the bright luster and more pleasing appearance that are demanded by the consumers, polishing is also done. The tedious processes involved in cleaning unhulled

rice with modern rice mills has been fully described by Fraps (1916), and further information can be obtained locally by writing to representatives of manufacturers of this machinery. In the Islands the "kiskisan" and the "cono" mills are very common; these afford one of the ways with which local consumers prepare their rice for consumption. However, in places where these rice mills are inaccessible, the farmers clean their rice with the use of the crude native implements mentioned above, where only the glumes and hulls, as well as awns if present, are removed and the brown unpolished rice is consumed direct.

As one of the by-products during the milling process of rice in preparing it for human consumption, we have the rice bran commonly known locally as "darak". Chemical composition of this by-product has been given by Fraps (1904, 1906) for Texas, U.S.A. Camus (1921) mentions several uses of the rice bran, such as, feeds for animals, etc. Santos (1933) has microscopically and microchemically examined rice bran as this is locally utilized in the manufacture of a medical preparation known as "tiki-tiki", an anti-beriberi medicine for infants and adults.

The texture of the rice bran locally sold in the market depends on the kind of mill used; that from cono mill is usually finer (Pl. 20, fig. 144), while that from the kiskisan mill is coarse (Pl. 20, fig. 141). The coarse bran includes the hulls, bran, polish, germs and broken grains. In cono bran the hull is not included and ground, but is separated and discarded so that the bran is a fairly distinct product. The pure rice bran should compose of the outer layer of the rice kernel proper togther with the germs and a very small amount of the hulls not separated in the milling process (Henry and Morrison, 1928), but when adulterated with finely ground hulls its purity becomes low and its adaptability as feed is thus lowered too. In fact Studds, Dodson and Brown (1904) entertain the fear that excess of the finely ground rice hulls in the stomach of the animals may cause extreme irritation of the delicate linings of the wall.

Chemical analyses of local rice brans obtained from cono and kiskisan mills are given by Tirol (1933), and Rivera (1936). Aguanta (1937) gave a similar chemical analysis of a rice bran he used for fattening his pigs, and presumably he was referring to cono rice

bran. His data approximate the averages obtained from those figures given by Tirol and Rivera, as given below.

	Standard rice bran (cono)		*Coarse rice rice bran (kiskisan)*
	From Tirol and Rivera per cent	*From Aguanta per cent*	*From Tirol and Rivera per cent*
Moisture	9.92	9.20	10.33
Fats or ether extract	9.85	13.89	2.69
Ash	12.14	10.11	15.45
Protein (N × 6.25)	11.27	12.38	4.83
Crude fiber	10.73	9.72	25.03
Carbohydrates N. F. E. 45	45.49	44.70	41.64

According to Rivera (1936) data on averages of milling percentages of paddy rice of two varieties, Hambas and Ramai, as furnished by Professor Vicente B. Aragon of the Department of Agronomy. showed the following:

	Cono Mill per cent	*Kiskisan Mill per cent*
Polished rice	64.32	59.25
Rice bran	10.21	37.11
Hulls	25.23	1.00
Shorts or binlid	0.23	2.59
Impurities	0.01	0.05

According to these data kiskisan rice bran contains approximately 60 per cent hulls and 40 per cent bran. In few kiskisan mills the bran (Pl. 20, fig. 141) is usually caught by a sieve which sifts the large pieces of the hulls and some rice polish or binlid (Pl. 18, fig. 134) and this gives us a bran of finer texture (Pl. 20, fig. 143).

Examinations of cross sections of polished rice made by Santos (1933) showed that the embryo is usually absent and the pericarp, seed coats and embryo and most of the aleurone layer, together with portions of the endosperm in extreme cases, are removed. In other words, a great amount of the nutritious portions of the kernel is removed during milling and polishing. In fact, in the United States in producing approximately one billion pounds of polished rice (average annual yield) the approximate removal of one hundred million pounds of its constituent is removed by polishing (LeClerc, 1932). These contain twenty million pounds of fat, twelve and a half million pounds of protein, and nine million pounds of mineral ingredient—all disposed as feed. One thing of interest is the fact that glutinous rice is appreciably richer in fat and fiber and heavier than are the common rice, but it is not always richer in protein.

After polishing the only remaining portion of the kernel usually utilized for human consumption is the bulk of the starchy endosperm. In the United States polished rice is regarded as having better keeping qualities than the brown rice (Le Clerc, 1932), but in Japan when it is necessary to carry rice from one season to another, brown rice and not polished rice is stored. The endosperm cells are rich in starch which closely resemble those of oats in form and size (Leath, 1920), but spindle-shaped forms are not present. The starch grains are united to form aggregates (Pl. 11, fig. 96; Pl. 29, fig. 184) similar to those of oats. Rice does not possess any gluten similar to that found in wheat (Copeland, 1924), and dough is never formed by rice flour unless it is adulterated with wheat flour.

From the point of view of an animal husbandman it would be of interest to know the tissue or tissues from where the rice bran which he uses as feed for his animals comes from. In wheat, for example, where the tissues of the kernel are easily separable (Bessey, 1894) the determination of distinct layers is comparatively easy. Examinations of cono rice bran submitted to us by the Department of Animal Husbandry, College of Agriculture, show the presence of fragments derived from the pericarp, seed coat, aleurone layer, part of the endosperm and embryo. In a few instances, however, larger or smaller pieces of the hull are also found in the bran (Pl. 21, fig. 146; Pl. 23, fig. 159 and 160), and these get into it accidentally or are purposely added. Stigmas are also present (Pl. 21, fig. 147). Results of microscopical examination of mature rice grains by the writers reveal the following interesting points regarding the tissue or tissues from where the rice bran is obtained: The kernel or caryopsis during milling and polishing loses parts of its outer portion and the tissues thus removed can be separated into distinct layers (text-figure 1). The first and outermost tissue is the bulk of the compressed cells of the pericarp (ovary wall) which constitutes the first bran layer. The pericarp at its innermost portion possesses tubular cells which are inconspicuous in either longitudinal and transverse section but are only detectable in surface view (Pl. 12, fig. 101). This cell layer constitutes the second bran layer, below which lies a thick coat composed of the outer tangential walls of the epidermis of the nucellar tissue, the perisperm. This coat, together with the compressed cells from the inner integument or seed coat, form the third bran layer. The seed coat apparently becomes lost at maturity of the rice kernel as this is incorporated in the perisperm. In polishing not only the three bran layers enumerated

forming typical caps. Increase in size at the phloem pole occurs in the peripheral bundles of the internode, basal bundles of the leaf sheath and those found at the blade joint. In the blade the bundle sheath becomes conspicuously large, more regular and it contains chloroplasts. The leaf bundles possess a fibrous inner sheath, in addition to the outer chlorophyllous sheath cells, the development of the former being directly correlated with the size of the bundle.

The epidermis of the stem and lateral organs consists of two types of cells: the long, wavy-walled cells and the short rectangular to oblong cells. The epidermis of the ligule and the auricle consists of only long cells. The epidermis as well as cortical cells of the internode of the mature stem becomes lignified. The epidermis of the leaf sheath, internode and the blade bears hairs and stomata typical to the grasses.

The vascular tissue of the root forms a siphonostele, bounded externally by the cortex, and internally by the pith. Peripheral cortical cells become suberized, forming the exodermis below which is a sclerenchymatous cylinder. The xylem plates of the root are separated from the endodermis by a single layer of pericyle. The cortex is extensive in primary adventitious roots, and it becomes least developed in fine lateral rootlets.

Primordia of nodal adventitious roots become microscopically visible five to six days from transplanting and these arise at intercalary meristem and at the nodal region. Development of epidermal prolongations from the embryo during the early stage of germination of the rice grain was detected. The lowermost axillary bud activates about seven days after transplanting, and becomes macroscopically visible out of the subtending sheath in about twenty-four to thirty days after transplanting, or thirty-one to thirty-seven days after planting the seeds in seed beds.

The coleoptile which degenerates very early, possesses two poorly developed vascular bundles which are embedded in a ground parenchyma.

The peduncle to the inflorescence presents a structural feature very similar to that of the internode of the stem except that it has no lacunae. At the first nodal region bearing the rachillae, the peduncle is not hollow; in this nodal region is a more extensively developed inner band of vascular bundles which tend to be crowded together around the central region occupied by distinctly stellate cells. The epidermis and cortex become lignified. On the epidermis are found trichomes and stomata similar to those formed in the other vegetative organs of the plant.

The rachis is hollow and is irregular in outline. It possesses two distinct bands of vascular bundles. The rachilla is grooved, and is traversed by four to five distinct bundles which form a solid mass at its center, the central bundle being the largest. The pedicel is nearly rounded and four vascular bundles run through it, the three enclosing the central large bundle. In all these organs of the inflorescence the epidermis as well as the cortex form a solid sclerenchyma cylinder.

The development of the rachillae to the inflorescence is acropetal. The organs of the spikelet arise in the following sequence: lemma and upper empty glume, palea and lower empty glume, stamens, pistil, and lodicules. Differentiation of the inflorescence initial takes place in about 23 days before its emergence out of the last leaf or flag.

The development of the megasporange, megaspore mother cell, and embryo is normal and follows very closely those reported by other investigators. The embryo sac is of the normal octonucleate type.

Fertilization is porogamous and the pollen tube enters the embryo sac by way of the micropyle, passing between the two synergids where it discharges its contents.

The development of the microsporange is normal and follows those reported in many angiosperms. Division of the microspore mother cell is successive. Long before anthesis the young microspore contains two coats, a thin peripheral cytoplasm, wherein a single nucleus is embedded, and a single germ pore.

Biological observations on the spikelets show that in Inapostol rice opening or anthesis, begins at 9. a. m. and ceases at a little after 11 a. m. During cloudy and rainy days opening may be delayed until 1 to 2 p. m., and at times opening is dispensed with (cleistogamy). Maximum dehiscence usually occurs at ten thirty in the morning. The duration of time that the spikelets remain practically open is the same on clear days as in cloudy days. This phenomenon is due, perhaps, to the angle of divergence of the palea and lemma during anthesis. During bright days the spikelets are more widely open than during cloudy days. It takes from two to five days on the average for all the spikelets in a panicle to open. Blooming proceeds from the top of the panicle downward and from the end of the panicle branch to its base.

The empty glume shows a single poorly developed vascular bundle at its thickest portion, where there may be seven or more layers of cells, thinning to one layer towards its margins. Its epidermis

possesses stomata. Trichomes are present along the margins. At maturity the cells become strongly lignified. Elongated, thick-walled, toothed parenchyma or short, plane ones are present. Parenchyma with distinct minute teeth or protuberances are also present in the glumes.

The lemma and palea present a nearly identical structural feature, the former possessing five vascular bundles, and the latter, three, all of which are poorly developed. The epidermal cells are large, the outer ones exhibiting uneven growth on their outer tangential walls. This feature is responsible for the development of crosswise intersecting rows of small tubercles on the lemma and palea. The inner epidermal cells become obliterated as the lemma and palea mature. On the epidermal layers are borne small globular trichomes; on the outer epidermis long, sharp trichomes are developed. The mature outer epidermal cells are large, the lateral walls of which are toothed, giving the cells a jagged, comb-shaped appearance; these become thick-walled and thick silicious deposits are laid out on their outer tangential walls. Sclerenchymatous cells are found beneath the outer epidermis, and these cells may either be provided with one or two rows of teeth, while the others are simply plane sclerenchyma. The parenchyma are either thick-walled, with wavy outline, or short and thin-walled. Trichomes of varying lengths are often present in the macerated material.

The awn, which is not well-developed in this variety, is traversed by a single central bundle, embedded in a fundamental tissue of ground parenchyma. This central ground parenchyma is surrounded by a sclerenchymatous cylinder consisting of the epidermis and six to seven layers of hypodermal cells. The epidermal cells are long, slender, and thick-walled.

Macerated rudimentary glumes show the presence of oblong to rounded, or elongated parenchyma and plane or wavy and irregularly toothed sclerenchyma.

The endosperm is of the nuclear type and its development follows the conventional. Surrounding the endosperm is an aleurone layer which may be one- to five-layered.

The seed coat is derived from the innermost epidermis of the inner integument, and this persists for some time during the development of the caryopsis. At maturity of the kernel, however, this persistent inner epidermis of the inner integument is pressed down, loses its identity and becomes incorporated to the perisperm.

The nucellus, which is scanty, is absorbed by the endosperm and its outer epidermis persists until about maturity of the caryopsis. This epidermis becomes obliterated and is represented in the mature kernel by their relatively thick outer tangential walls, known as the perisperm with which the seed coat is incorporated.

The pericarp is derived from the ovary wall and is traversed by three vascular bundles. At the dough stage the inner hypodermal cells contain chloroplasts, while its inner epidermis as well as one to two layers of hypodermal cells become tubular. However, the innermost layer is the only one that persists at maturity of the caryopsis and its identity can only be determined on surface section. In the mature caryopsis the pericarp cells are dead and dry, and remain as layers of collapsed cell walls.

The rice bran has been microscopically examined. Rice bran from "kiskisan" rice mills is coarser than that from "cono" rice mills, because of the fact that a greater percentage of the ground hull goes with the bran in this by-product from the former mill. Cono rice brans examined show the absence of fructose, dextrine and glucose, while starch, oil, and silica are present in considerable amount. Results of comparative microscopical and microchemical examinations of two cono rice brans are given.

The tissues from which rice bran are derived from the mature caryopsis are (1) the bulk of the dried cell walls of the pericarp, (2) the innermost layer of the pericarp, known as tubular cells, (3) the perisperm and seed coat, (4) aleurone layer, and (5) starchy endosperm. The first three groups of tissues may be called the bran layers. The fourth and fifth tissues are removed during polishing. With those groups of tissues given above, small or large fragments of the hull and trichomes as well as the embryos, which are easily knocked off during milling, may be incorporated. Adulteration of cono rice bran with ground hulls can easily be done, and this is usually detected with fair accuracy by microscopical examination.

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EXPLANATION OF PLATES

(Most of the drawings were made by the junior author. Figures 123–133, 135, 137–140, 142, and 151 were taken by Mr. Jesus Redondo, of the Department of Botany, College of Liberal Arts, University of the Philippines. The rest of the microphotographs were taken by the senior author either with the use of the apparatus in the Department of Botany, College of Liberal Arts, University of the Philippines, or that in the Photographic Division, Soils Department, College of Agriculture, University of the Philippines.)

PLATE 1

Fig. 1. Diagram of a lateral view of a portion of the stem showing part of the lower internode (*in*), node (*no*), and sheath joint (*sj*). × 3.5.

2. Sketch of the same stem cut longitudinally to show the basal portion of the internode enclosed by the leaf sheath; *im*, intercalary meristem; *in*, internode; *no*, node; *sj*, sheath joint. × 3.5.

3. Auricle enlarged; *tr*, trichomes, or hairs; *vb*, vascular bundles. × 8.

4. Diagram of a transverse section of the mature peduncle; *chl*, chlorenchymatous region; *ho*, hollow portion; *pa*, parenchyma region; *scy*, sclerenchyma cylinder; *vb*, vascular bundle. × 26.

5. Diagram of a transverse section of a mature rachis taken at its internodal region; *chl*, chlorenchymatous region; *ho*, hollow portion; *pa*, parenchyma region; *scy*, sclerenchyma cylinder; *vb*, vascular bundle. × 59.

6. Diagram of a transverse section of the mature peduncle taken at the region where the first primary branches (rachillae) are borne; *chl*, chlorenchymatous region; *pa*, parenchyma region; *scy*, sclerenchyma cylinder; *vb*, vascular bundle. × 26.

7. Sketch of a lateral portion of the leaf showing the auricle (*au*), blade joint or collar (*bj*), and ligule (*l*). × 2.5.

8. Diagram of a transverse section of the mature rachilla showing four vascular bundles (*vb*); *chl*, chlorenchymatous region; *scy*, sclerenchyma cylinder. × 59.

9. Diagram of a transverse section of another mature rachilla showing the presence of five vascular bundles (*vb*); *chl*, chlorenchymatous region; *scy*, sclerenchyma cylinder. × 59.

PLATE 2

Fig. 10. Diagram of a transverse section of a mature pedicel; *chl*, chlorenchymatous region; *scy*, sclerenchyma cylinder; *vb*, vascular bundles. × 59.

11. Surface section of a portion of the epidermis of an internode from a mature stem showing attachment of a two-celled trichome. × 890.

12. Surface section of a portion of the epidermis from an internode of a mature stem showing the large and small cells. Note the relative thickness of the epidermal cell walls. × 890.

13. Surface section of the epidermis from the node of a mature stem showing the two types of cells. × 890.

14. Surface section of a mature stoma from the internode of the stem; *gc*, guard cells; *p*, stomatal pore; *sgc*, subsidiary guard cells. × 1050.

15. Surface section of the epidermis from the intercalary meristen of a mature stem. × 890.
16. Surface section of the epidermis of the internode showing attachment of one-celled trichome. × 890.
17. Surface section of the outer epidermis of a mature leaf sheath showing the small paired cells. ×1060.
18. Surface section of a portion of the outer epidermis of a mature leaf sheath showing a one-celled trichome and its attachment. × 1060.
19. Surface section of a portion of the outer epidermis of a mature leaf sheath showing two-celled trichome and its attachment. × 1060.

PLATE 3

Fig. 20. Surface section of the inner epidermis of a mature leaf sheath showing a stoma. × 590.
21. Surface section of the outer epidermis of the sheath joint. × 590.
22. Surface section of the upper epidermis (morphologically the inner) of the blade joint showing a stoma and a small cell. × 1060.
23. Surface section of the upper epidermis of a mature leaf blade showing attachment of a small unicellular trichome. × 590.
24. Portion of a transverse section of the leaf blade at its margin; *chl*, chlorenchymatous mesophyll cells; *lep*, lower epidermis; *scl* sclerenchymatous cells; *uep*, upper epidermis. × 590.
24a. Portion of the commissural bundle embedded in a mass of stellate cells found in the air chambers of the mature leaf sheath. × 112.
25. Surface section of the upper epidermis of the leaf blade showing stomata; stippled cells and one to two adjoining layers of epidermal cells are above a vascular bundle. × 590.
26. Surface section of the outer (morphologically the lower) epidermis of the blade joint. × 590.
27. Surface section of the lower epidermis of the leaf blade showing distribution of stomata; stippled cells and one adjoining layer of cells are above a vascular bundle. × 590.

PLATE 4

Fig. 28. Portion of a transverse section of the leaf blade showing a stoma at its upper surface; *ach*, air chamber; *ep*, epidermal cell; *gc*, guard cell; *sgc*, subsidiary guard cell. × 1060.
29. Portion of a transverse section of the leaf blade showing a stoma at its lower surface; *ach*, air chamber; *ep*, epidermal cell; *gc*, guard cell; *sgc*, subsidiary guard cell. × 1060.
30. Portion of a transverse section of the leaf blade showing a modified upper epidermal cell above a vascular bundle. × 1060.
31. Surface section of the upper epidermis of the leaf blade showing attachment of a large trichome. × 590.
32. Surface section of the outer epidermis of a young lemma. × 590.
33. Surface section of the outer epidermis of a mature palea. × 590.
34. Surface section of the inner portion of a mature lemma. × 590.
35. Surface section of the outer epidermis of a mature lemma. × 590.

PLATE 5

Fig. 36. Diagram of a longitudinal section of a young inflorescence showing the hyaline trichomes and young rachillae or primary branches (*ra*). × 26.

37. A larger inflorescence; *ra*, rachillae. × 26.
38. Longitudinal section of a young spikelet showing upper empty glume (*ugl*) and the lemma (*le*). × 112.
39. An older spikelet showing the upper (*ugl*) and lower (*lgl*) empty glume, lemma (*le*), and beginnings of the stamens (*st*). × 112.
40. Another spikelet showing the stamens (*st*) differentiating and the beginnings of the palea (*pa*); *le*, lemma; *lgl*, lower empty glume; *ugl*, upper empty glume. × 112.
41. A much older spikelet with its stamens (*st*) much more differentiated; *le*, lemma; *lgl*, lower empty glume; *pa*, palea; *ugl*, upper empty glume. × 112.
42. A still older spikelet showing the stamens (*st*) elongating and forming their filaments and anthers; *le*, lemma; *lgl*, lower empty glume; *pa*, palea; *ugl*, upper empty glume. × 112.
43. A nearly mature spikelet with its lemma (*le*) very much enlarged; *lgl*, lower empty glume; *pa*, palea; *pe*, pedicel; *pi*, pistil; *st*, stamens; *ugl*, upper empty glume. × 112.
44. Longitudinal section of a young pistil showing the beginnings of the formation of the ovary wall (*ovw*). × 112.
45. An older ovary showing the beginnings of the megasporange and the formation of its first integument (*ii*); *n*, nucellus; *ovw*, ovary wall. × 112.
46. A spikelet showing all its parts; *le*, lemma; *lgl*, lower empty glume; *pa*, palea; *pi*, pistil; *st*, stamens; *ugl*, upper empty glume. × 26.
47. Showing portion of the ovary from where the megasporange arises giving rise to the style (*sty*); *ii*, inner integument; *n*, nucellus; *ovw*, ovary wall. × 112.
48. Diagram of a transverse section of the ovary showing the megasporange with two integuments; *es*, embryo sac; *ii*, inner integument; *l*, locule; *oi*, outer integument; *ovw*, ovary wall. The three vascular bundles on the ovary wall are stippled. × 410.
49. Longitudinal section of the ovary showing the megasporange at tetrad stage; *ii*, inner integument; *l*, locule; oi, outer integument; *ovw*, ovary wall; *sty*, style. × 112.
50. A similar section of the ovary showing the embryo sac at binucleate stage; *es*, embryo sac; *ii*, inner integument; *l* locule; *oi*, outer integument; *ovw*, ovary wall. × 112.
51. Portion of a longitudinal section of a megasporange showing two-celled archesporium. × 590.
52. Another megasporange showing normal one-celled archesporium. × 590.

PLATE 6

Fig. 53. Portion of a longitudinal section of a megasporange showing the megaspore mother cell in synapsis. × 890.

54. A dyad. × 1060.
55. Dyad in anaphase division. × 1060.

56. Tetrads; chalazal megaspore enlarging, while the three micropylar sister cells show plasmolysis and degeneration. × 1060.
57. Showing degenerating micropylar sister megaspores and chalazal one being functional. × 1060.
58. Binucleate embryo sac. Note vacuole formation. × 1060.
59. Quadrinucleate embryo sac. × 1060.
60. Octonucleate embryo sac. Note differentiation of the antipodals (*an*); *pn*, polar nuclei. × 890.
61. A nearly mature embryo sac. Note the binucleate condition of the antipodal cells (*an*); *me*, megagamete; *pn*, polar nuclei; *sy*, synergids. × 590.
62. Portion of the chalazal end of an embryo sac showing multinucleate antipodal cells (*an*); *pn*, polar nuclei. × 590.

PLATE 7

Fig. 63. A mature embryo sac prior to fertilization and anthesis. Note the multicellular antipodals (*an*); *me*, megagamete; *pn*, polar nuclei; *sy*, synergids. × 1060.

64. Showing the presence of pollen tube (*pt*) and the sperm nuclei (*spn*) in the embryo sac; *me*, megagamete; *pn*, polar nuclei; *sy*, synergid degenerating. × 590.
65. Degenerating antipodals. × 590.
66. Egg apparatus of the sac from fig. 64, showing primary endosperm nucleus, zygote, and degenerating synergid; *pn*, polar nuclei; *sy*, synergid; *zy* zygote. × 590.
67. Portion of a longitudinal section of a young caryopsis when the zygote is three-celled; *ii*, inner integument; *n*, nucellus; *oi*, outer integument; *per*, pericarp; *tc*, tubular cells. × 590.
68. Portion of a longitudinal section of a young caryopsis at the multinucleate stage of the endosperm; *chl*, chlorenchymatous cells; *en*, endosperm nuclei; *ii*, inner integument; *n*, nucellus; *per*, pericarp; *tc*, tubular cells. × 590.
69. Portion of a longitudinal section of a young caryopsis at the beginning of the cellular endosperm formation; *chl*, chlorenchymatous cells; *en*, endosperm cells; *ii*, inner integument; *n*, nucellus; *per*, pericarp; *tc*, tubular cells. × 590.
70. Portion of a longitudinal section of a caryopsis showing cellular endosperm; *chl*, chlorenchymatous cells; *en*, cellular endosperm; *per*, pericarp; *ii*, inner integument; *n*, nucellus; *tc*, tubular cells. × 590.

PLATE 8

Fig. 71. Portion of a longitudinal section of an older caryopsis; *al*, aleurone layer; *chl*, chlorenchymatous cells; *en*, cellular endosperm; *ii*, inner integument; *n*, nucellus; *per*, pericarp; *tc*, tubular cells. × 590.

72. Portion of a longitudinal section of a much older caryopsis with cellular endosperm almost filling up the embryo sac; *al*, aleurone layer; *chl*, chlorenchymatous cells; *en*, cellular endosperm; *ii*, inner integument; *n*, nucellus; *per*, pericarp; *tc*, tubular cells. × 590.

73. Portion of a transverse section of the wall of a young ovary showing one of the vascular bundles; *iep*, inner epidermis; *oep*, outer epidermis. Note the size of the inner epidermal cells. × 590.
74. Two-celled zygote; free endosperm nuclei in the sac; *sy*, degenerating synergid. × 890.
75. Four-celled zygote; free endosperm nucleus at its vicinity. × 890.
76. An older proembryo. Note presence of numerous free endosperm nuclei (*en*); *emb*, proembryo. × 540.
77. Basal portion of a nearly mature embryo showing differentiated suspensor cells (*sc*) stippled. × 540.

PLATE 9

Fig. 78. Portion of a transverse section of a microsporange showing one-celled archesporium. × 1060.
79. Showing two-celled archesporium in a microsporange. × 1060.
80. Showing microspore mother cells in transverse section; note shrinkage from the parietal tissue and the distinct uninucleate condition of the tapetal cells (*t*). × 890.
81. Portion of a longitudinal section of a microsporange showing microspore mother cells at resting condition. Note shrinkage of the mass of mother cells from the parietal tissue; *t*, tapetum. × 890.
82. Portion of a longitudinal section of a microsporange showing microspore mother cells rounding off and shrinking from the walls, their nuclei beginning to form spiremes; *t*, tapetum. × 890.
83. Portion of a longitudinal section of a microsporange showing microspore mother cells in metaphase stage of the heterotypic division; note binucleate tapetal cells (*t*). × 890.
84. Dyad in metaphase stage of the homotypic division. × 890.
85. Tetrads. × 890.
86. Tetrads which have rounded off and beginning to separate. × 890.
87. Young microspore long before anthesis showing its contents; *ex*, exine; *in*, intine; p, pore. × 890.
88. Showing portion of a longitudinal section of the scutellum and few epithelial cells; *en*, endosperm cells; *ept*, epithelial cells; *sct*, scutellum. ×590.
89. Transverse section of a nearly mature anther showing four microsporange; *ep*, epidermis; *mi*, microspores; *t*, tapetum; *vb*, vascular bundles at the connective. × 235.

PLATE 10

Fig. 90. Reconstructed diagram of a longitudinal section of a mature grain showing parts; *ap*, apiculus; *al*, aleurone layer; *bl*, bran layers; *col*, coleoptile; *colr*, coleorhiza; *ept*, epithelium; *le*, lemma; *lgl*, lower empty glume; *pa*, palea; *pl*, plumule; *ra*, radicle; *rc*, root cap; *sc*, scutellum; *sen*, starchy endosperm; *sty*, remnant of the style and stigma; *ugl*, upper empty glume; *vb*, vascular bundle. × 75.
91. Portion of a longitudinal section of the lemma showing origin of a trichome; *oep*, outer epidermis; *si*, silica deposit; *tr*, trichome. × 540.

92. Portion of a longitudinal section of the periphery of the caryopsis; *al*, aleurone layer; *per*, pericarp; *pem*, perisperm and seed coat; *sen*, starchy endosperm cells; *tc*, tubular cells. × 540.

92a. Stigma found between the hull (palea and lemma) and the caryopsis in the mature grain. Note remnants of pollen mass. × 53.

PLATE 11

Fig. 93. Portion of a longitudinal section of a young lemma at its basal portion showing differentiation of its epidermal layers; *iep*, inner epidermis; *oep*, outer epidermis. × 540.

94. Portion of a longitudinal section of the lemma showing the beginnings of the thickenings of the walls of the outer epidermal cells and further enlargement of the inner epidermal cells; *iep*, inner epidermis; *oep*, outer epidermis; *tr*, trichome. ×410.

95. Portion of a longitudinal section of the lemma between the apiculus and its base showing attachment of a trichome; note increase in number of cell layers in the section; *iep*, inner epidermis; *oep*, outer epidermis; *tr*, trichome. × 410.

96. Different aggregates of starch grains from mature endosperm of the caryopsis. × 540.

97. Portion of a transverse section of the young palea at its thickest portion showing its vascular bundles. Note enlargement of the epidermal cells; *iep*, inner epidermis; *oep*, outer epidermis; *tr*, trichome; *vb*, vascular bundle. × 525.

PLATE 12

Fig. 98 Portion of a transverse section of the young lemma showing its middle vascular bundle. Note also enlargement of epidermal cells and presence of small, globular trichomes; *iep*, inner epidermis; *oep*, outer epidermis; *tr*, trichome; *vb*, vascular bundle. × 525.

99. Portion of a transverse section of the mature caryopsis showing parts; *al*, aleurone layer; *en*, starchy endosperm; *pem*, perisperm and seed coat; *per*, pericarp; *tc*, tubular cells. × 540.

100. Surface section of the inner epidermis of a young palea. × 525.

101. Surface section of a mature caryopsis; *al*, aleurone cells; *per*, pericarp cells; *tc*, tubular cells. × 540.

PLATE 13

Fig. 102. Portion of a transverse section of the mature lemma; *lu*, lumen of the cell; *si*, silica deposit. × 530.

103. Portion of a transverse section of the mature awn showing parts; *ep*, epidermis; *pa*, parenchyma fillers; *scy*, sclerenchyma cylinder; *vb*, central vascular bundle. × 540.

104. Portion of the caryopsis which adheres to the lemma; *al*, aleurone cells; *per*, pericarp cells. × 235.

105. Macerated material from a mature lemma showing parenchyma (*pa*), sclerenchyma (*scl*), and vessel (*v*). × 540.

PLATE 14

Fig. 106. Trichome from maceration of the mature palea. × 235.
107. Different types of macerated parenchyma from the mature palea. × 235.
108. Different types of sclerenchyma from macerations of the mature palea. (*a*) sclerenchyma with single row of teeth or protuberances; (*b*) plane sclerenchyma; (*c*) sclerenchyma with two rows of teeth but partially developed. × 235.
109. Macerated outer epidermal cells from the mature lemma. × 235.
110. Another similar cell from the mature palea. × 235.
111. Sclerenchyma with double rows of teeth or protuberances from maceration of mature palea. × 235.
112. Parenchyma with rather wavy walls from maceration of the mature lemma. × 235.
113. Sclerenchyma with two partially developed rows of teeth; one plane sclerenchyma is included from maceration of the mature lemma. × 235.
114. Different types of parenchyma from maceration of the mature palea. × 235.

PLATE 15

Fig. 115. Different types of cell elements from maceration of the mature empty glume. Note the characteristic features of their walls; one of them at the bottom (center) is a trichome. × 480.
116. Surface section (enlarged) of the outer epidermis of the empty glume. × 940.
117. Surface view of the inner epidermis of the empty glume. × 235.
118. Portion of a transverse section of the mature empty glume; *iep*, inner epidermis; *oep*, outer epidermis. × 410.
119. Surface section of the epidermis of the awn. × 235.
120. Sclerenchyma and a trichome from maceration of the mature awn. × 235.
121. Parenchyma from maceration of the mature awn. × 235.
122. Extremely elongated sclerenchyma and parenchyma from maceration of a mature awn. × 235.

PLATE 16

Fig. 123. Transverse section of a root previous to the destruction of its cortical tissue. × 85.
124. Portion of a transverse section of an older root showing degenerated cortex, and the stele. Note the presence of four metaxylem vessels; see also fig. 123. × 94.
125. Portion of a longitudinal section of a young seedling showing differentiation of a root primordium from its lowermost node. × 59.
126. Portion of a longitudinal section of the radicle showing differentiation of branch root primordia. × 88.

PLATE 17

Fig. 127. Longitudinal section of the growing point of the plant showing apical young inflorescence and the presence of an axillary bud to its right. Root primordium is present (not shown in the photograph) at the third node below the leaf. × 44.

128. Portion of a longitudinal section of a young seedling showing lowermost axillary bud which will form the primary tiller beginning to develop. × 74.
129. Portion of a longitudinal section of a young seedling showing nodal root primordium differentiating above the insertion of the leaf sheath. × 52.
130. Portion of a longitudinal section of a young seedling showing nodal root primordium differentiating below the insertion but at the upper portion of the node. × 77.

PLATE 18

Fig. 131. Portion of a transverse section of the intercalary meristem; note apparent thickenings of the walls of the pith cells and the presence of an abundance of starch grains. Light cells are parenchymatous. × 43.
132. Portion of a transverse section of a young internode of the stem. Note the presence of air lacuna between the vascular bundles. × 75.
133. Transverse section of a mature auricle taken about the middle showing the presence of three vascular bundles; the bundle above represents the two bundles which are undergoing fusion. Note the trichome at its lower portion. × 105.
134. Photograph of a thin film of the hull and middlings separated by sieving the "kiskisan" rice bran from fig. 141. Slightly reduced.
135. Portion of a transverse section of a nearly mature node of the stem. Note the thickness of the cortical tissue. × 54.

PLATE 19

Fig. 136. Portion of the mature auricle from fig. 137 showing one of the vascular bundles. × 280.
137. Transverse section of the mature auricle cut below its middle portion showing the three vascular bundles. × 124.
138. Portion of a transverse section of the blade joint at one of its upper corners showing arrangement of its vascular bundles and the presence of extensive air lacunae. × 124.
144. Photograph of a thin film of "cono" rice bran No. 1 submitted by the Department of Animal Husbandry, College of Agriculture. Slightly reduced.

PLATE 21

Fig. 145. Transverse section of the basal portion of the coleoptile showing its vascular bundles. × 101.
146. Fragment of the hull from No. 2 cono rice bran submitted by the Department of Animal Husbandry. × 20.
147. Showing a stigma in No. 1 cono rice bran submitted by the Department of Animal Husbandry. × 46.
148. Portion of a transverse section of the empty glume showing its poorly developed vascular bundle. × 256.
149. Portion of a transverse section of a young leaf sheath. Note the arrangement of the cells at regions where air lacunae will be formed. × 107.

PLATE 22

Fig. 150. A transverse section of a single vascular bundle from the node. Note the enlargement of parenchyma surrounding it and the increase in xylem elements. × 104.

151. Transverse section of the leaf sheath joint just a short distance above its insertion to the stem. Note the strong development of sclerenchyma caps at their phloem pole and the absence of sclerenchyma masses at the two epidermal layers. × 69.

152. Transverse section of the midrib of the leaf blade. × 72.

153. Transverse section of the entire empty glume. × 111.

PLATE 23

Fig. 154. Portion of a transverse section of the first internode of the stem. Note the crowding of its vascular bundles towards the hole and the strong development of parenchyma towards its outer epidermis wherein large air lacunae are present. × 60.

155. Longitudinal section of the young inflorescence initial beginning to cut off lateral branches or rachillae. × 47.

156. Portion of a transverse section of the blade showing one large and a small vascular bundle between which is the hinge. Note the absence of colorless parenchyma between the chlorenchymatous mesophyll cells. × 112.

157. Portion of a transverse section of the coleoptile through one of its bundles showing compressed inner cells. × 243.

158. Portion of a longitudinal section of a young germinating embryo showing outgrowths from the epidermal cells of the tissue enveloping the plumule and the radicle. × 40.

159. Showing portion of a long slender fragment of the hull in No. 2 cono rice bran submitted by the Department of Animal Husbandry. × 61.

160. Another fragment of the hull in No. 2 cono rice bran submitted by the Department of Animal Husbandry. × 20.

PLATE 24

Fig. 161. Portion of a transverse section of an old root showing the outer exodermal layer, below which is the sclerenchyma cylinder; third layer of parenchyma inside represents cortical cells from where the strands of cortical cells separating the cortical lacunae are attached. × 382.

162. Portion of a transverse section of a mature peduncle cut at its internode showing its central hole and the distribution of its vascular bundles. × 53.

163. Portion of the stele of a root showing the metaxylem vessels and strands of protophloems and protoxylems; endodermis has not thickened yet and pith is scanty. × 382.

164. Portion of the transverse section of an older root showing lignification in the stele and differentiation of the walls of the endodermis. × 282.

165. Transverse section of a fine rootlet showing poorly developed stele, large cells of the pericycle, thickened cells of the endodermis, and one to two layers representing the cortex. × 448.

PLATE 25

Fig. 166. Portion of a transverse section of a young root near its apex showing the differentaition of tissues of the central cylinder. Note arrangement of the cortical parenchyma. × 371.

167. Portion of a transverse section of a mature ligule showing one of its vascular bundles. Note size and number of cells between the epidermal layers. × 250.

168. Transverse section of a branch root showing its similarity with that of the main adventitious root shown in fig. 124. Note poor development of its stele. × 233.

169. Transverse section of the mature rachis at its internode showing the hole inside and the distribution of its vascular bundles. × 51.

PLATE 26

Fig. 170. Portion of a transverse section of a mature rachilla showing the distribution of its vascular bundles and development of strong sclerenchyma. × 187.

171. Portion of a transverse section of a young internode prior to formation of air lacunae and lignification of its epidermal and cortical cells. × 51.

172. Portion of a transverse section of the stem near the node. Note the thickness of the cortex and the longitudinally cut vascular bundle. Lower cells show the presence of large intercellular spaces. × 50.

173. Another view of the empty glume shown in fig. 148 and 153. × 217.

PLATE 27

Fig. 174. Toothed and plane sclerenchyma from maceration of No. 2 cono rice bran submitted by the Department of Animal Husbandry. × 288.

175. Portion of a longitudinal section of a seedling at its nodal region showing longitudinally directed and transversely cut vascular bundles. Note the presence of pith cells to the right. × 26.

176. Portion of a transverse section of the leaf blade showing distribution of the bundles, hinges and presence of a trichome on its upper surface. × 156.

177. Portion of a transverse section of the mature peduncle taken at its first node where the first group of rachillae are borne. Note arrangement of the bundles and the presence of parenchyma at its center. × 49.

178. Transverse section of that part of the radicle embedded in the embryo. × 88.

PLATE 28

Fig. 179. Portion of a longitudinal section of the plant showing its growing apex to the left and an axillary bud to the right. × 92.

180. Transverse section of the embryo showing the vascular bundles coming from the radicle and its initial connection with the vascular supply to the plumule and the scutellum. × 88.

181. Transverse section of a young spikelet cut at the level of the style showing position of its parts; the two masses of cells located near the margins of the palea are the lodicules. Note relative sizes of the epidermal cells of both palea and lemma. × 54.

182. Another transverse section of the same radicle shown in fig. 178. × 88.

PLATE 29

Fig. 183. Sclerenchyma and parenchyma from macerations of the mature rudimentary glume. × 314.

184. A single cell from the starchy endosperm of a mature caryopsis showing its contents. × 1187.

185. Diagram of a transverse section of a young spikelet cut at the level of the ovary showing positions of its parts. Note the presence of vascular supply to the lodicules and their connection to the palea.; *fi*, filaments; *le*, lemma; *lgl*, lower empty glume; *lo*, lodicules; *meg*, megasporange with two integuments fully differentiated; *pa*, palea; *ovw*, ovary wall; *ugl*, upper empty glume, *vb*, vascular bundles. × 65.

186. Surface section of the inner surface of the mature palea. × 920.

187. Diagram of a longitudinal section of the spikelet showing distinctly all its parts; *ant*, anthers; *le*, lemma; *lgl*, lower empty glume; *lo*, lodicule; *fi*, filaments; *meg*, megasporange; *pa*, palea; *ped*, pedicel; *ovw*, ovary wall; *rgl*, rudimentary glume; *sty*, style; *ugl*, upper empty glume. × 37.

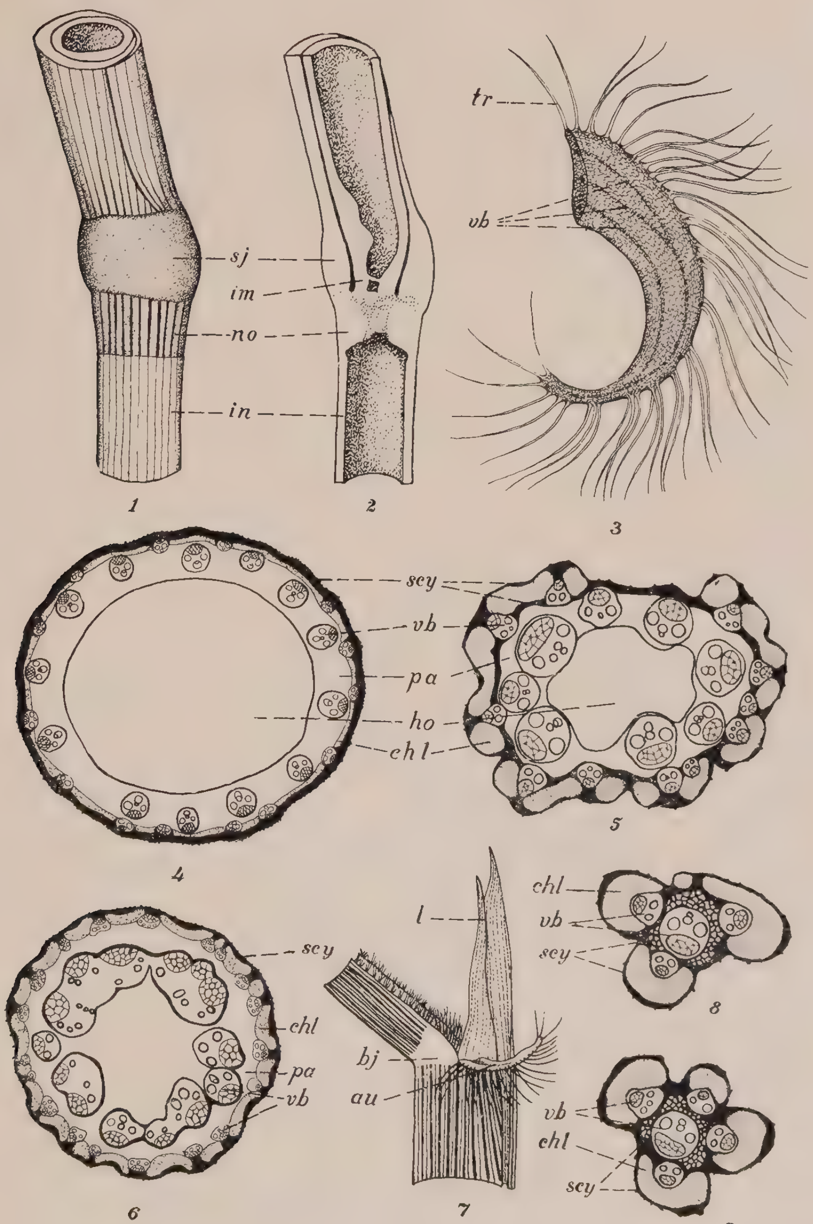
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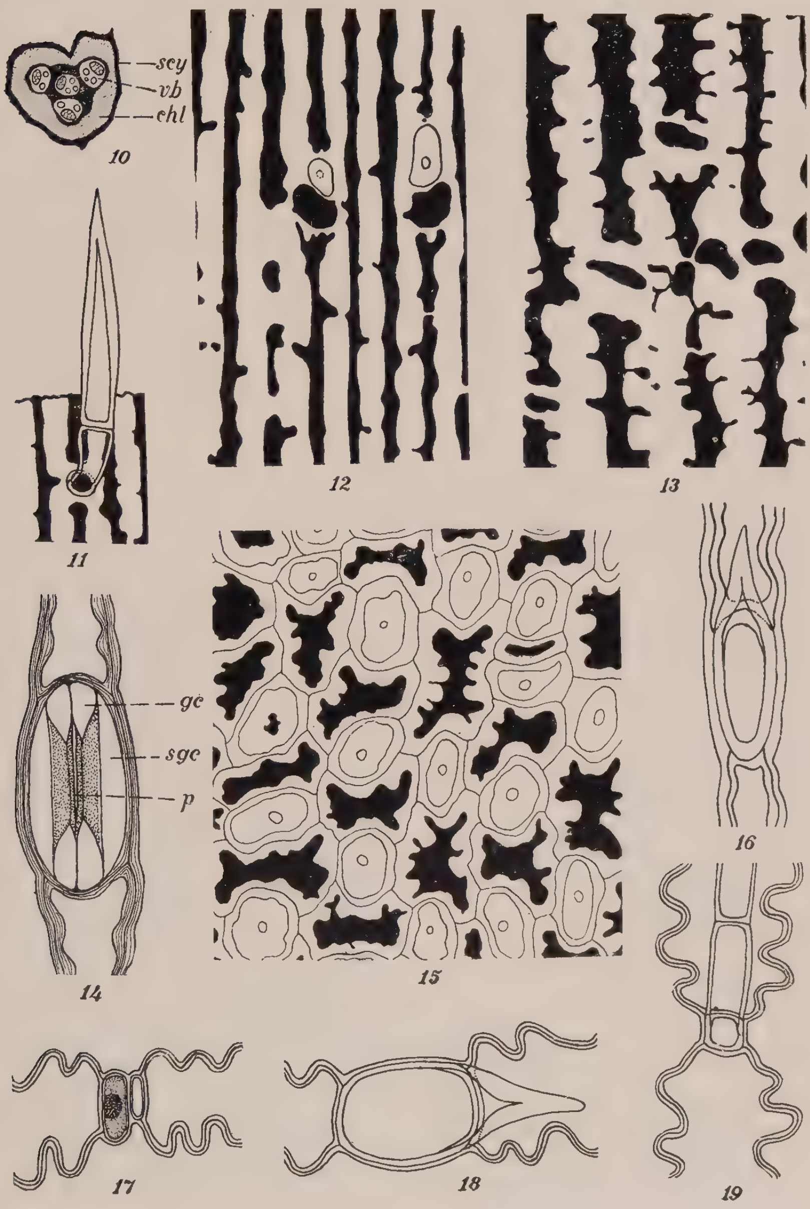
PLATE 1



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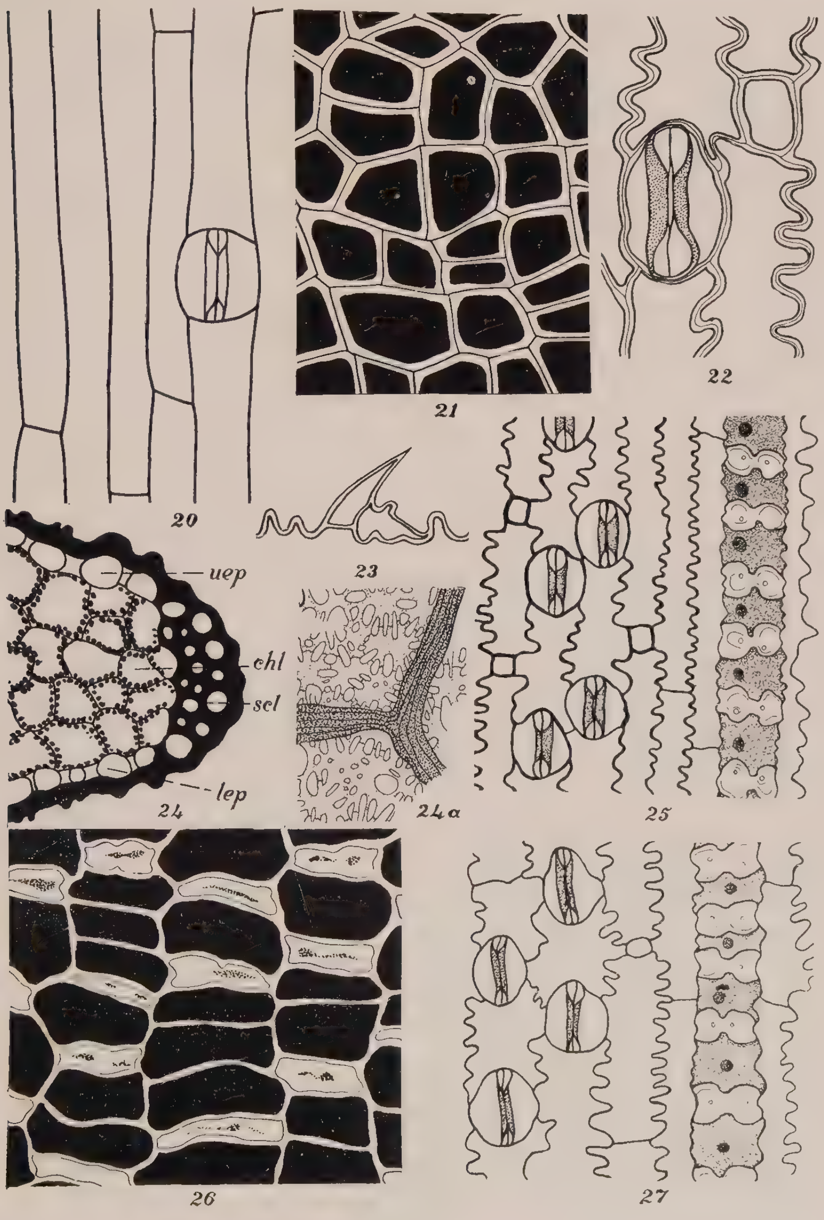

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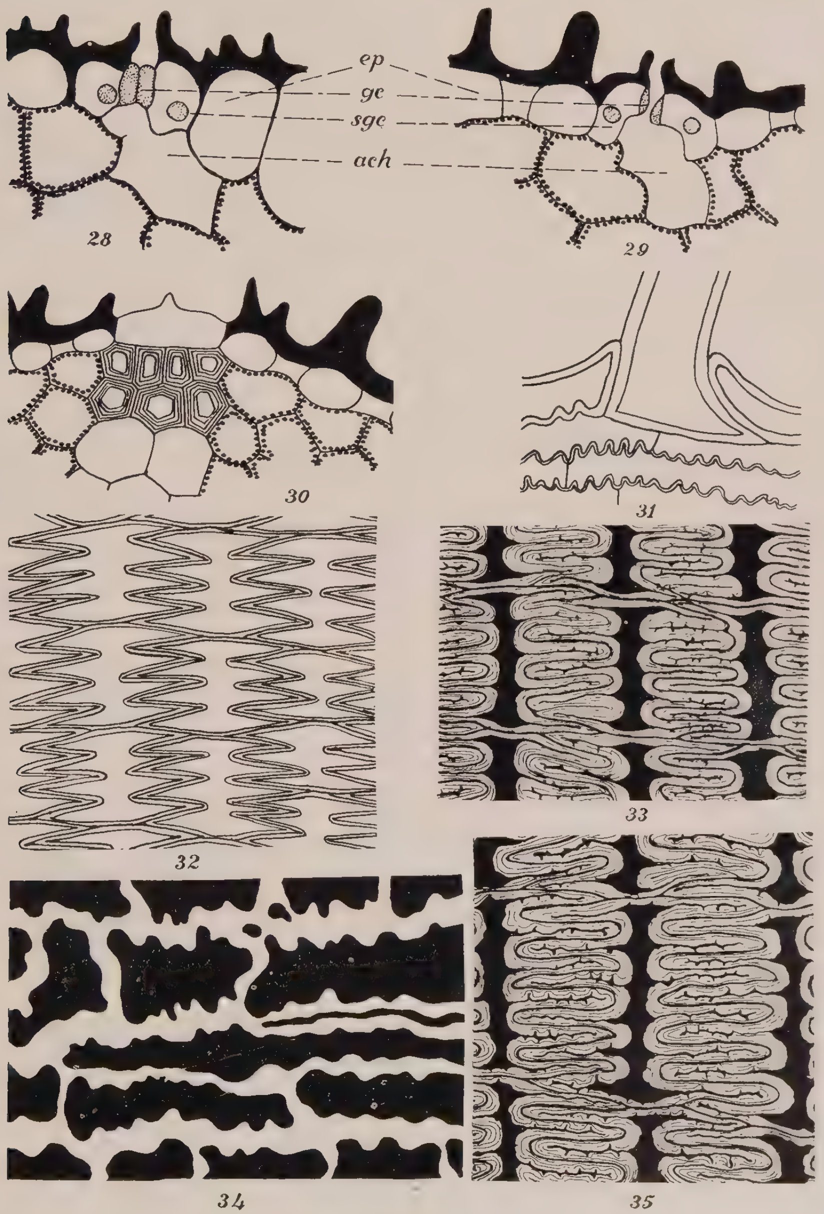

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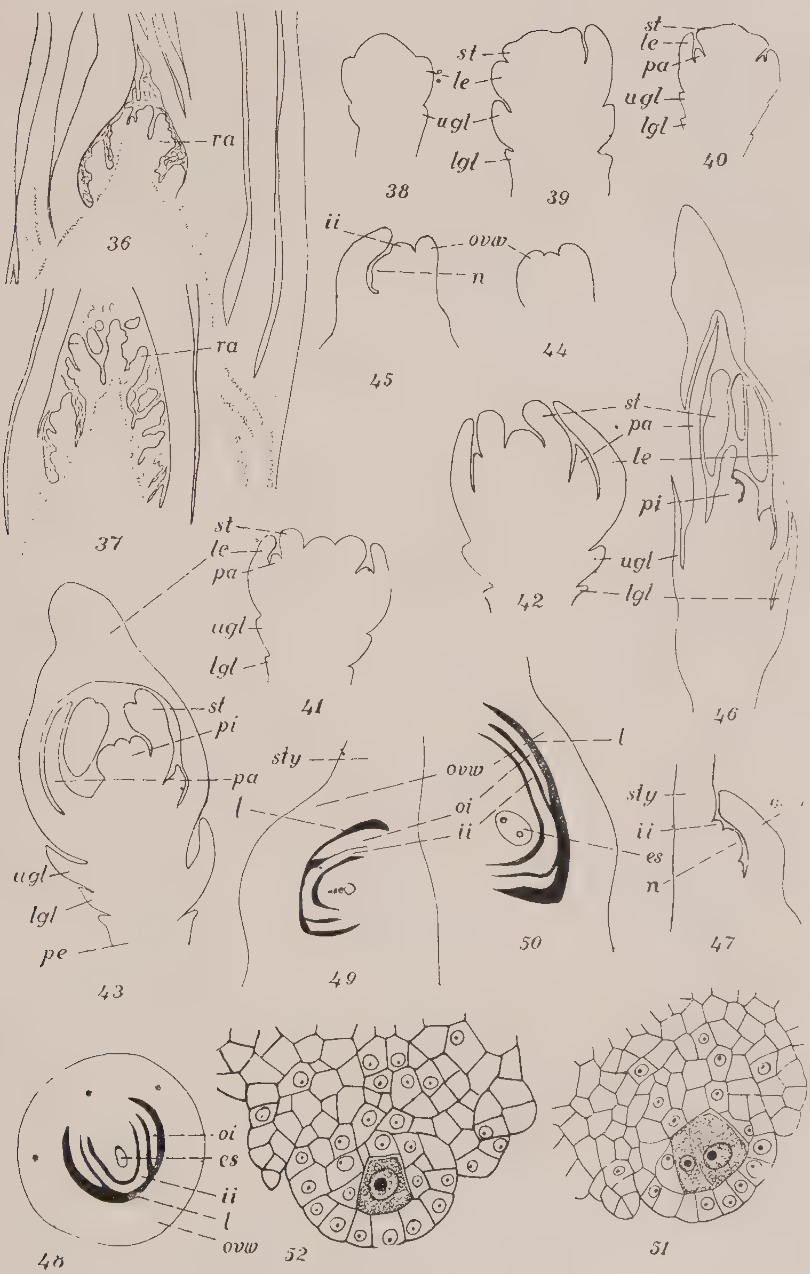
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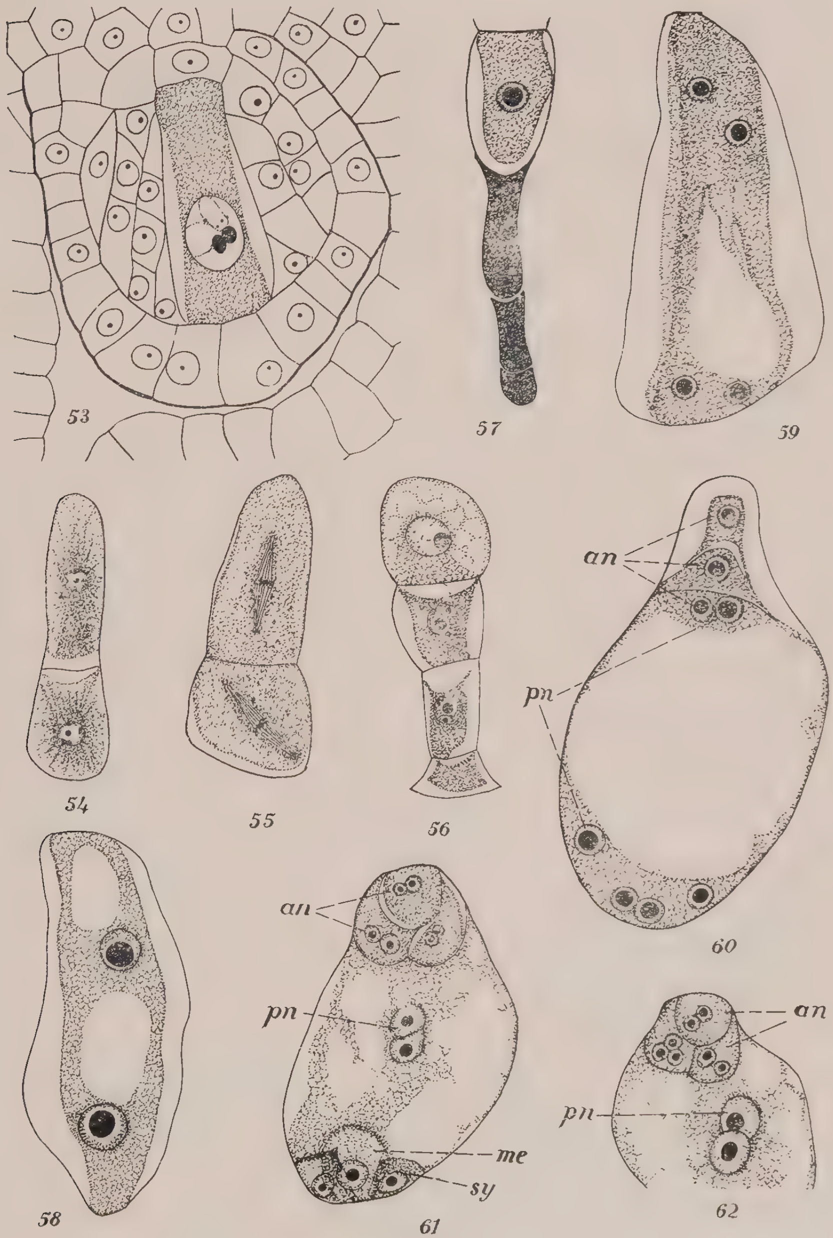

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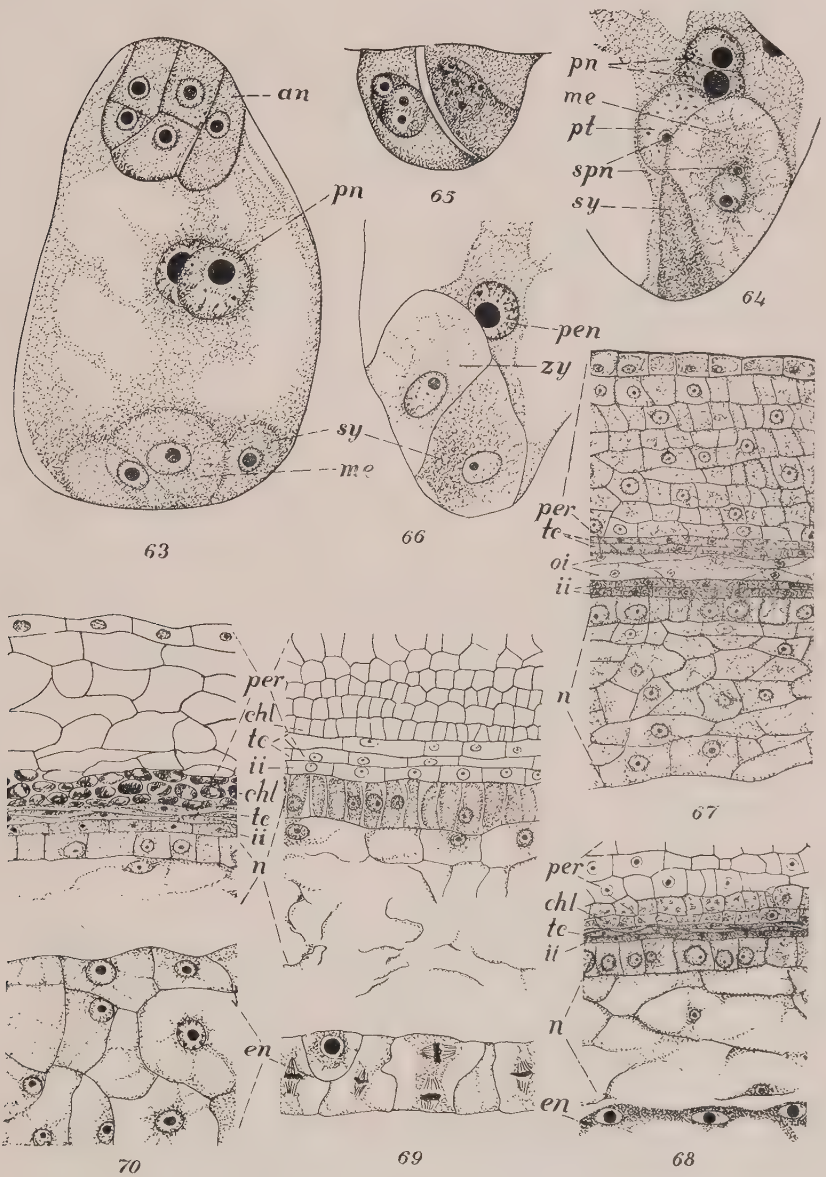
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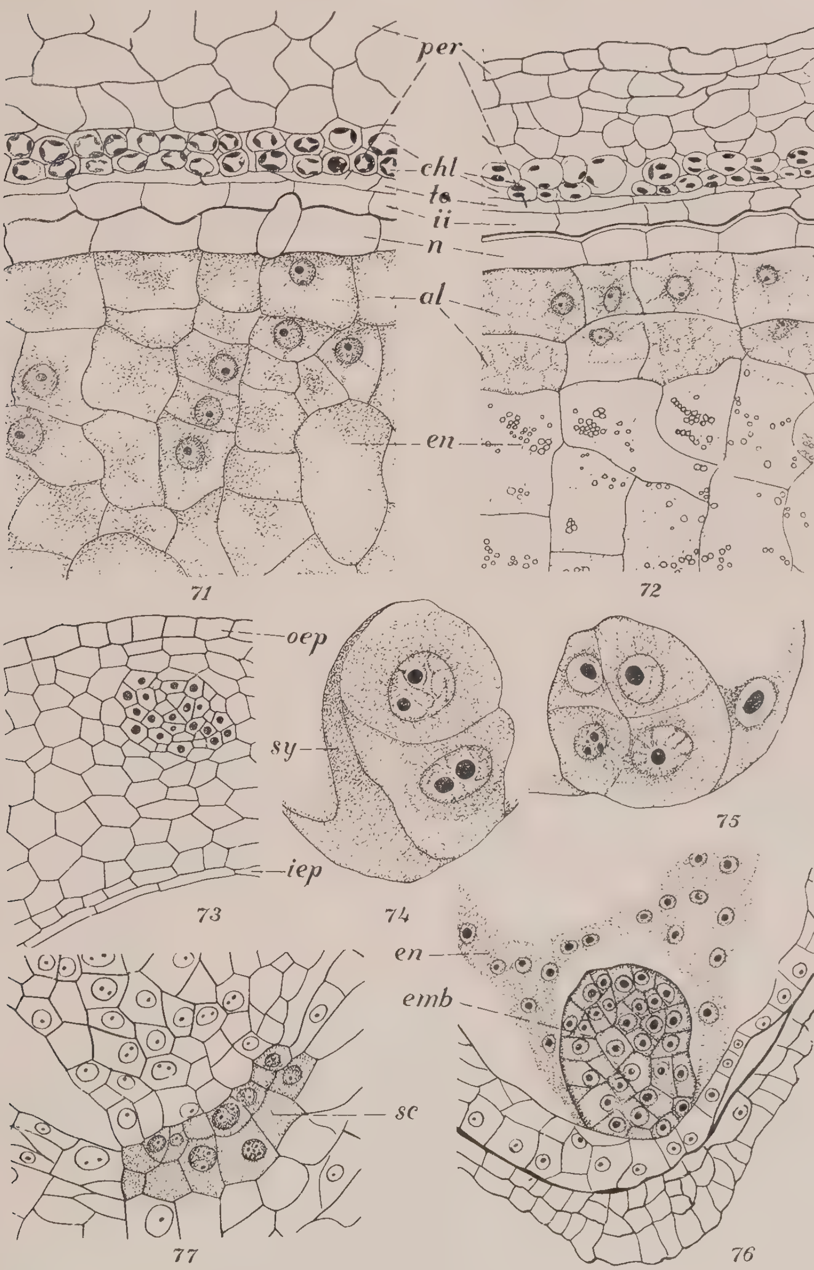
PLATE 7



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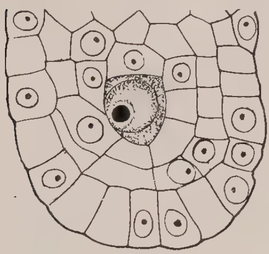

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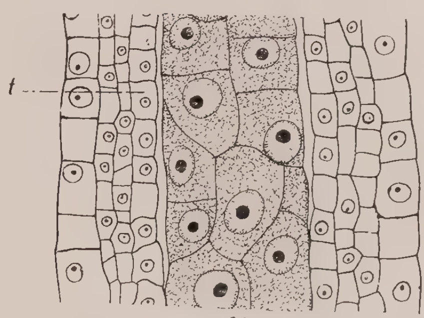

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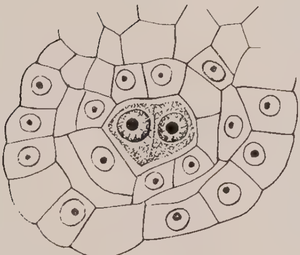

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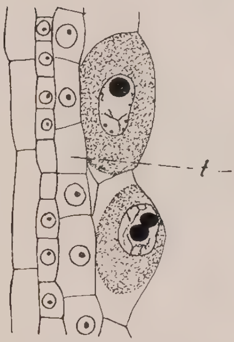

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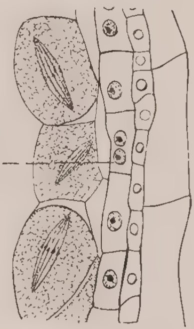

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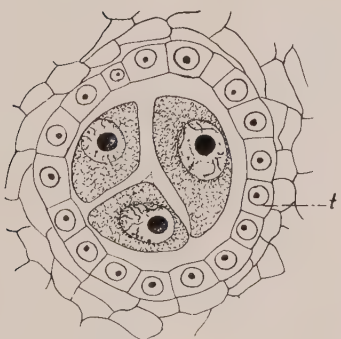

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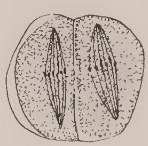

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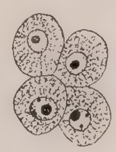

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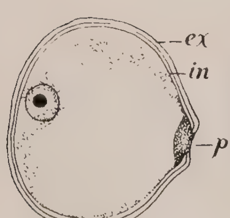

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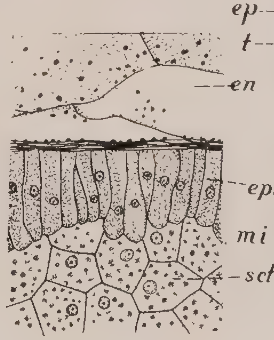

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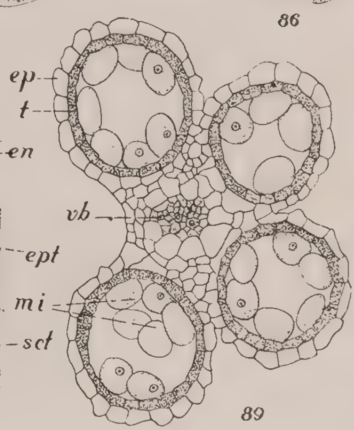

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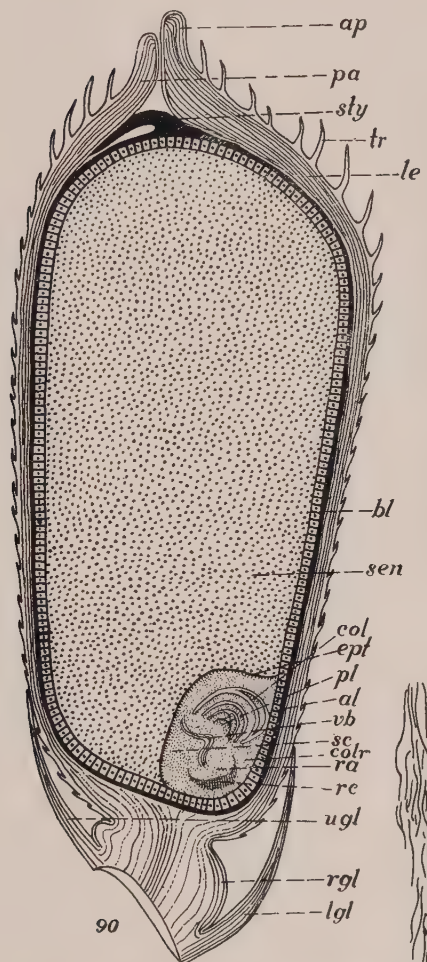
PLATE 9



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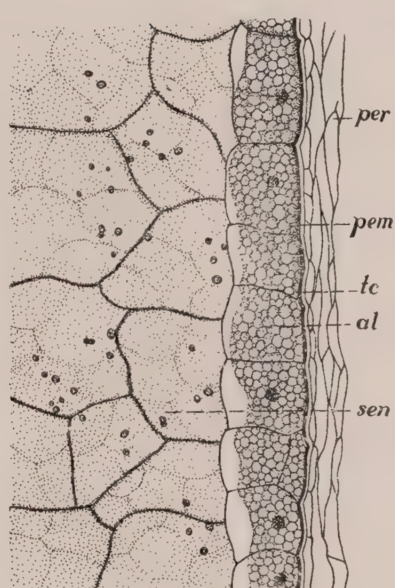

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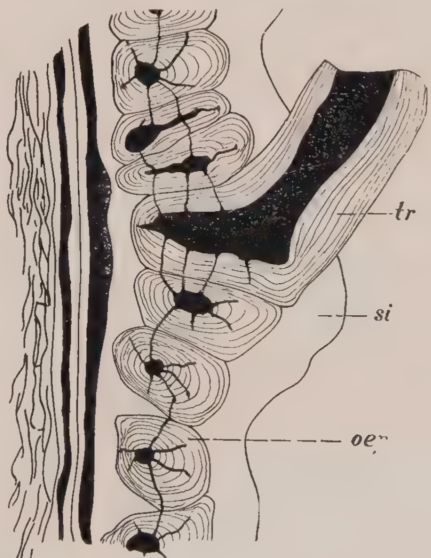

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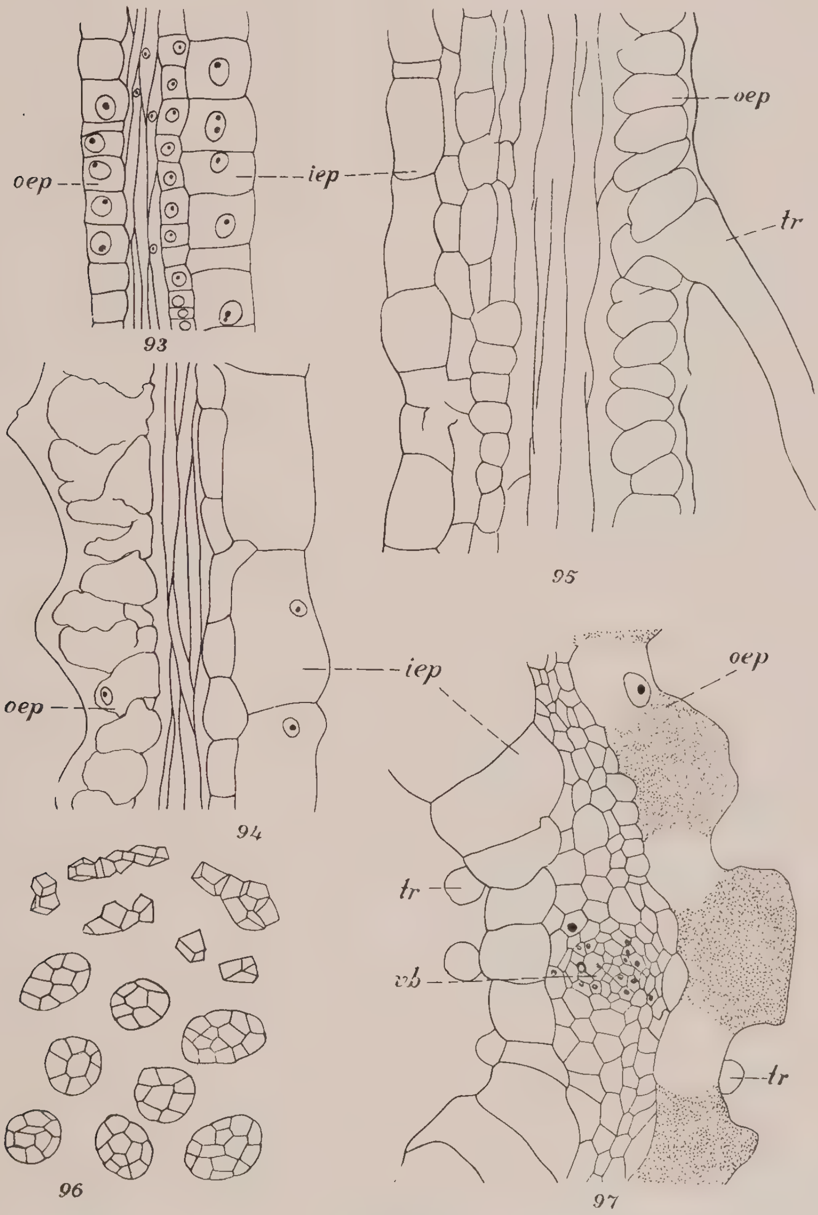
Plate 10



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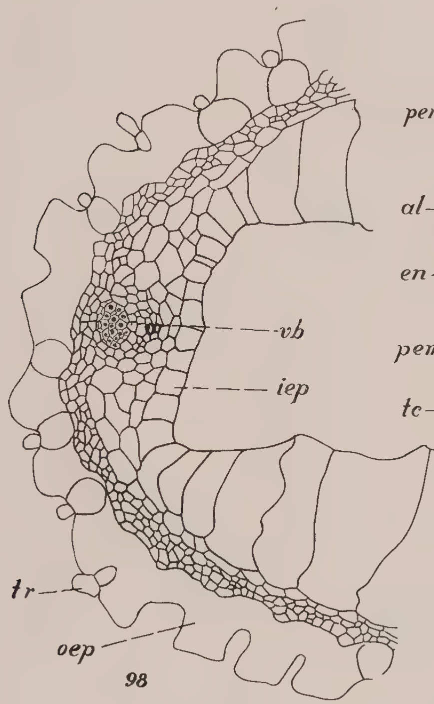

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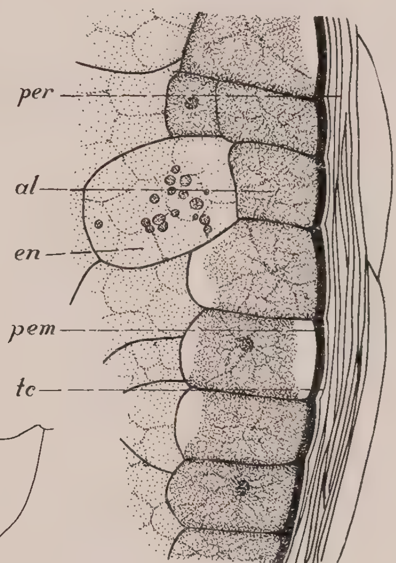

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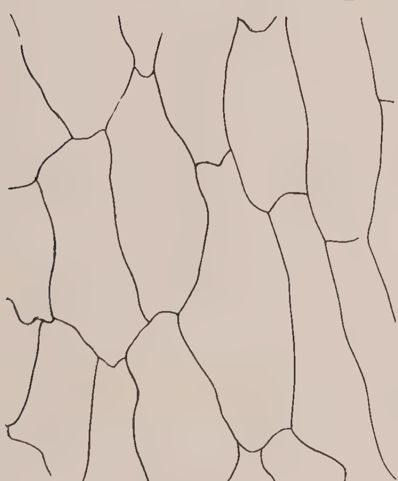

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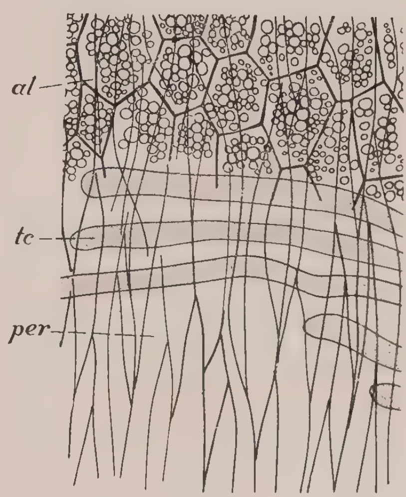

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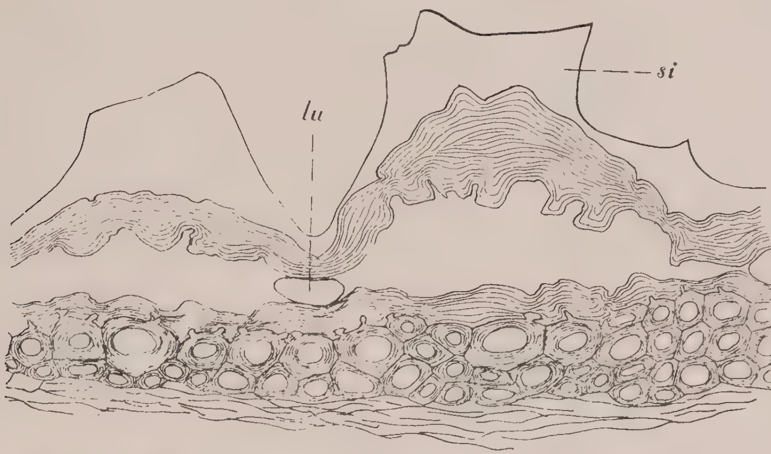

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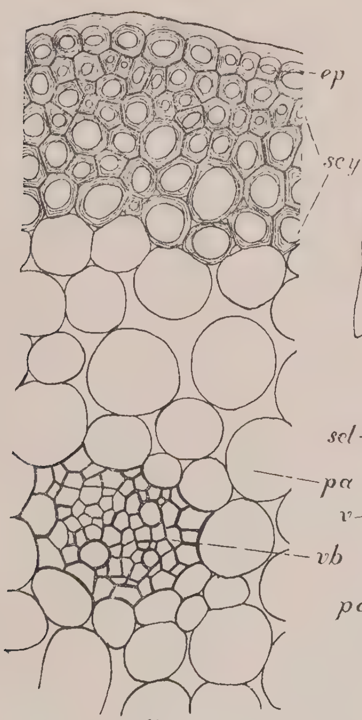

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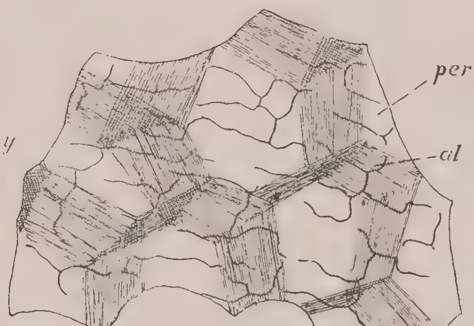

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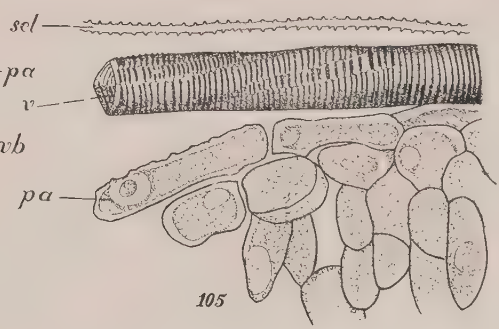

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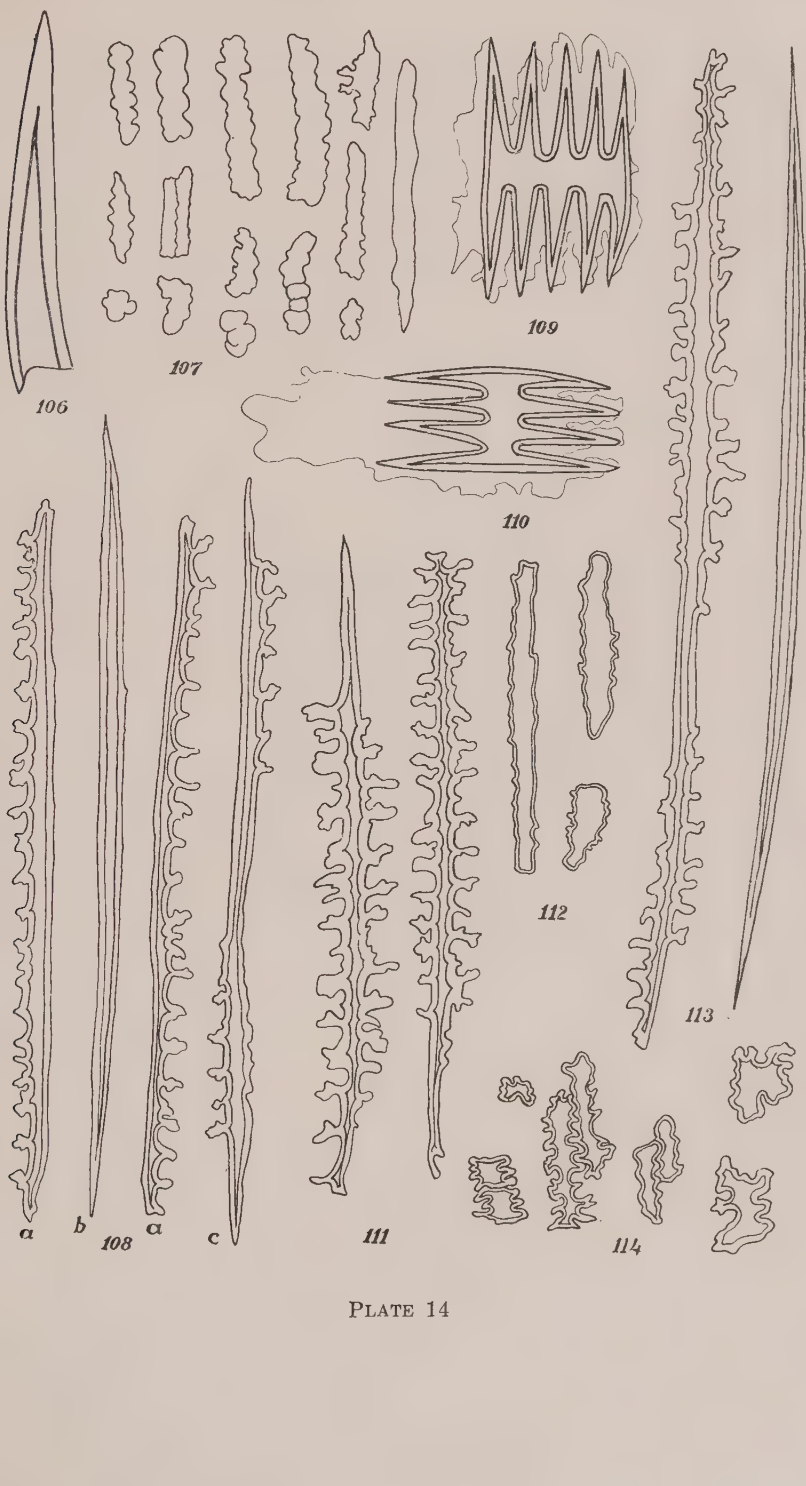

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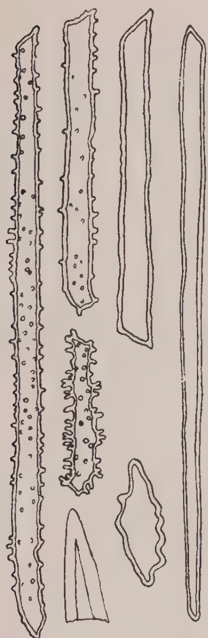

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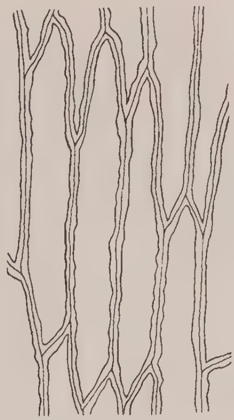

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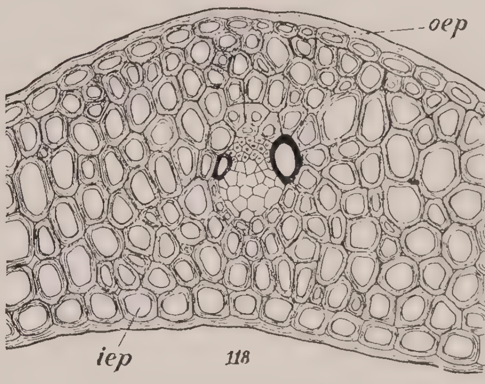

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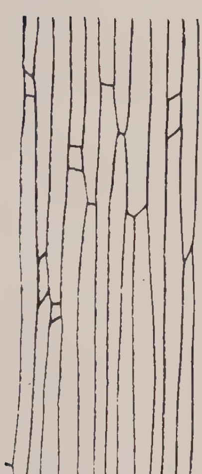

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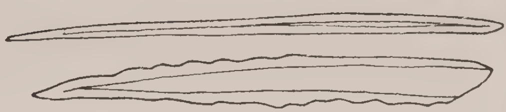

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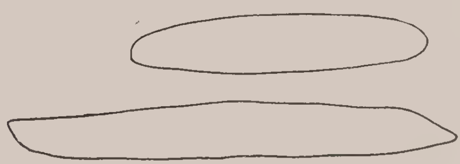

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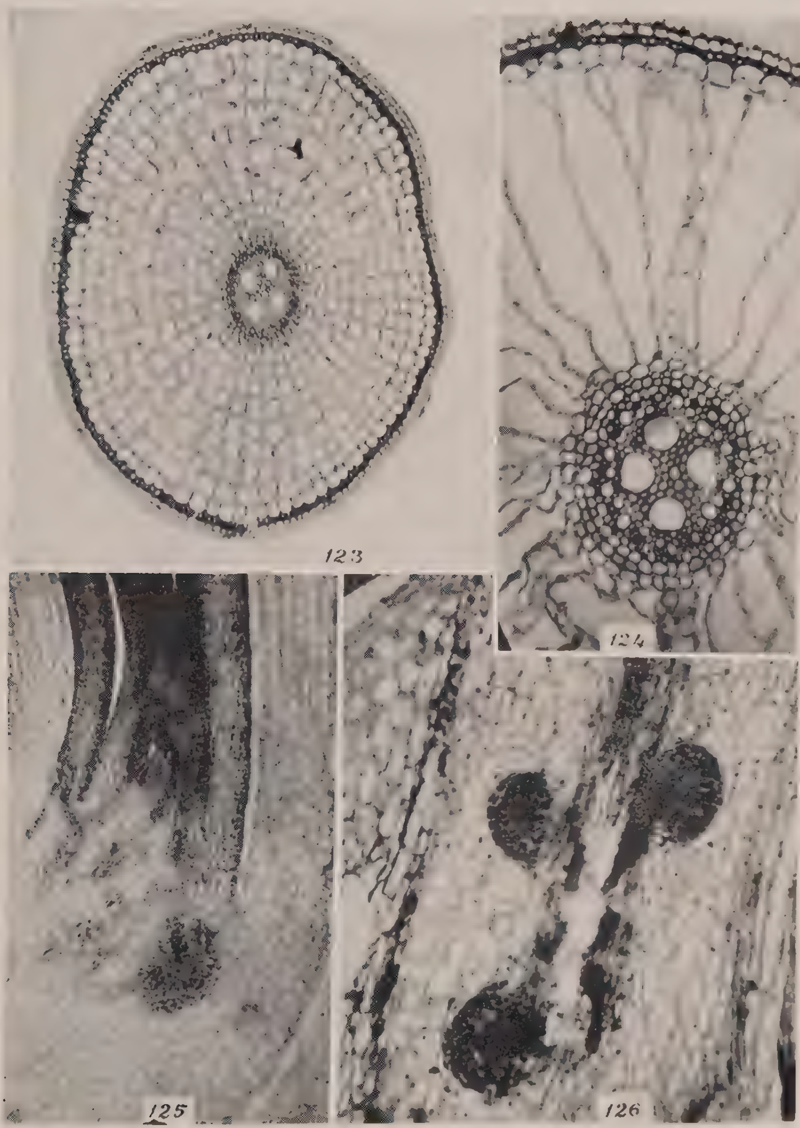

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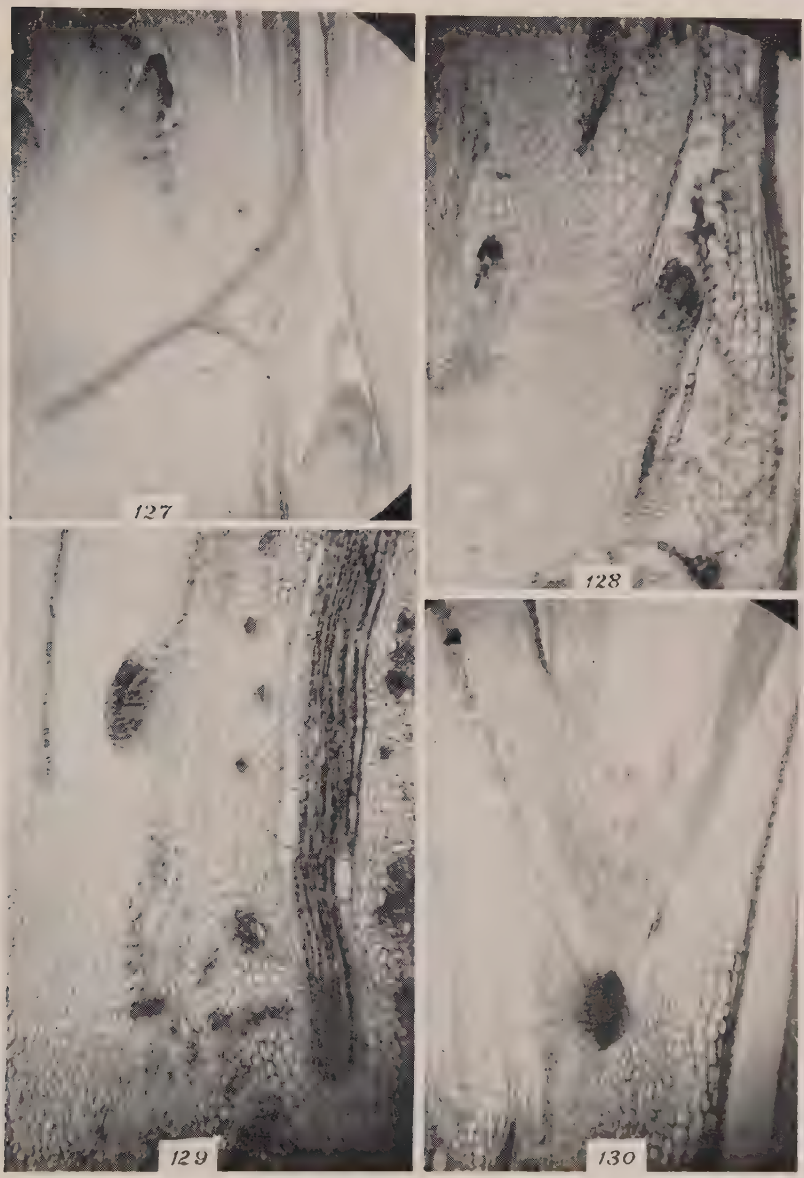

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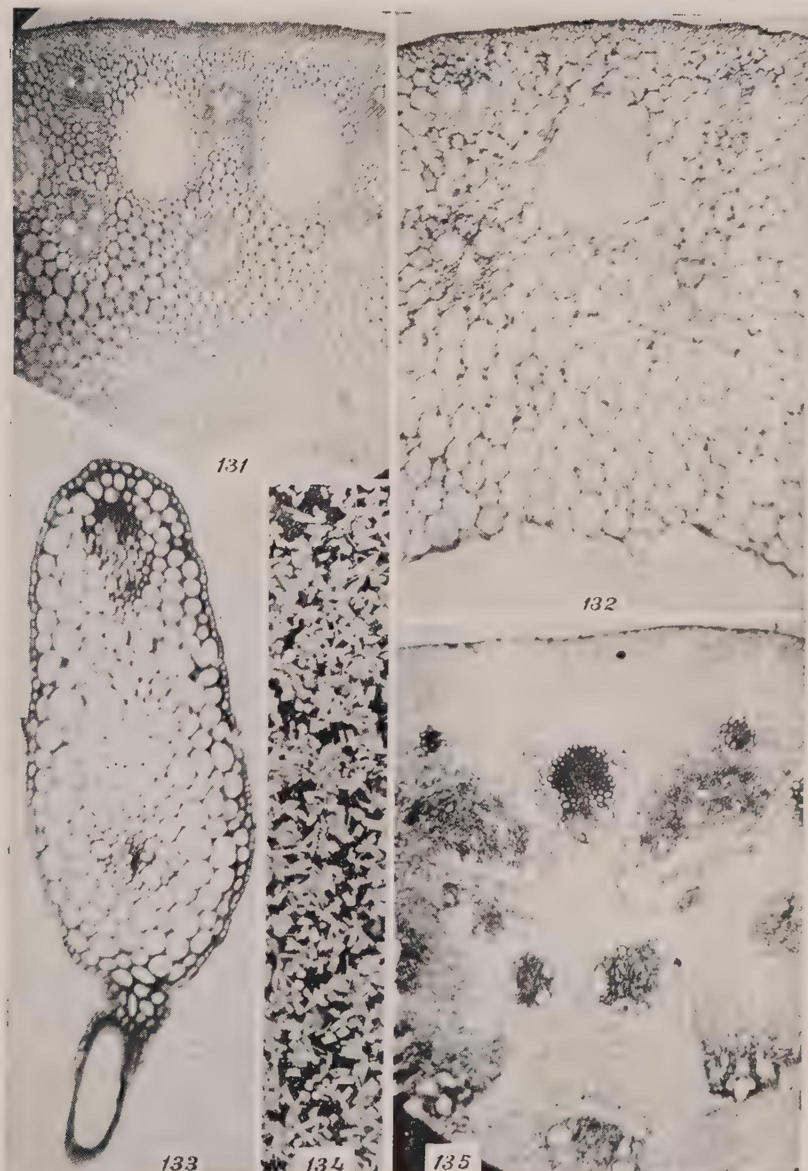

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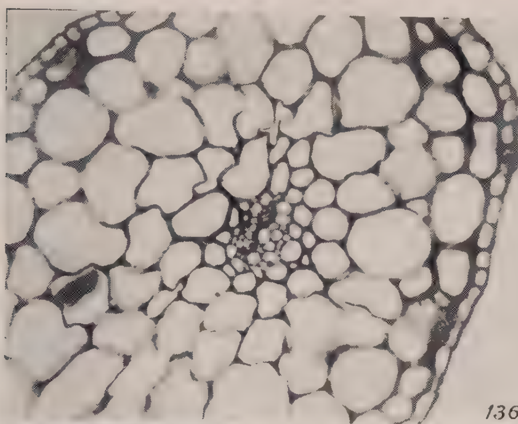

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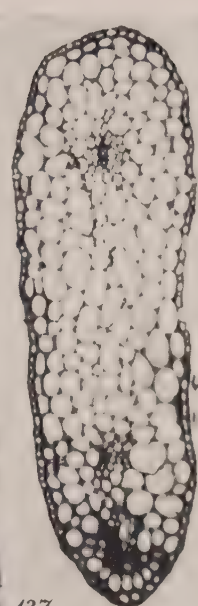

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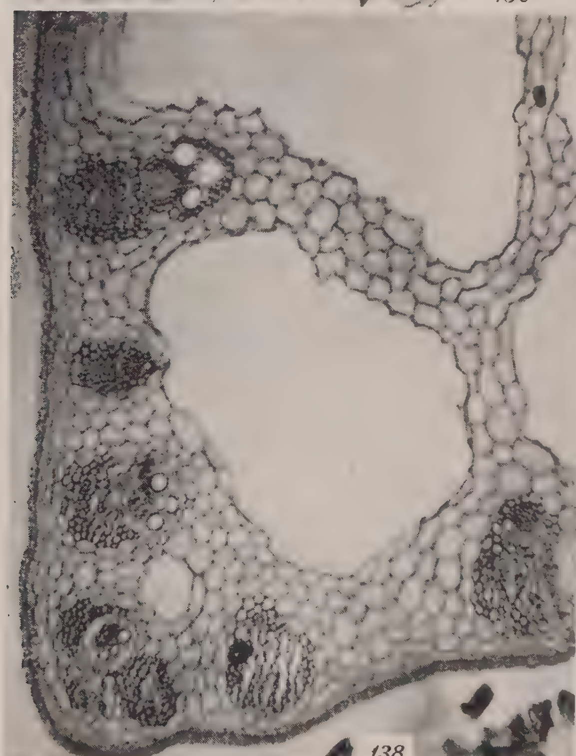

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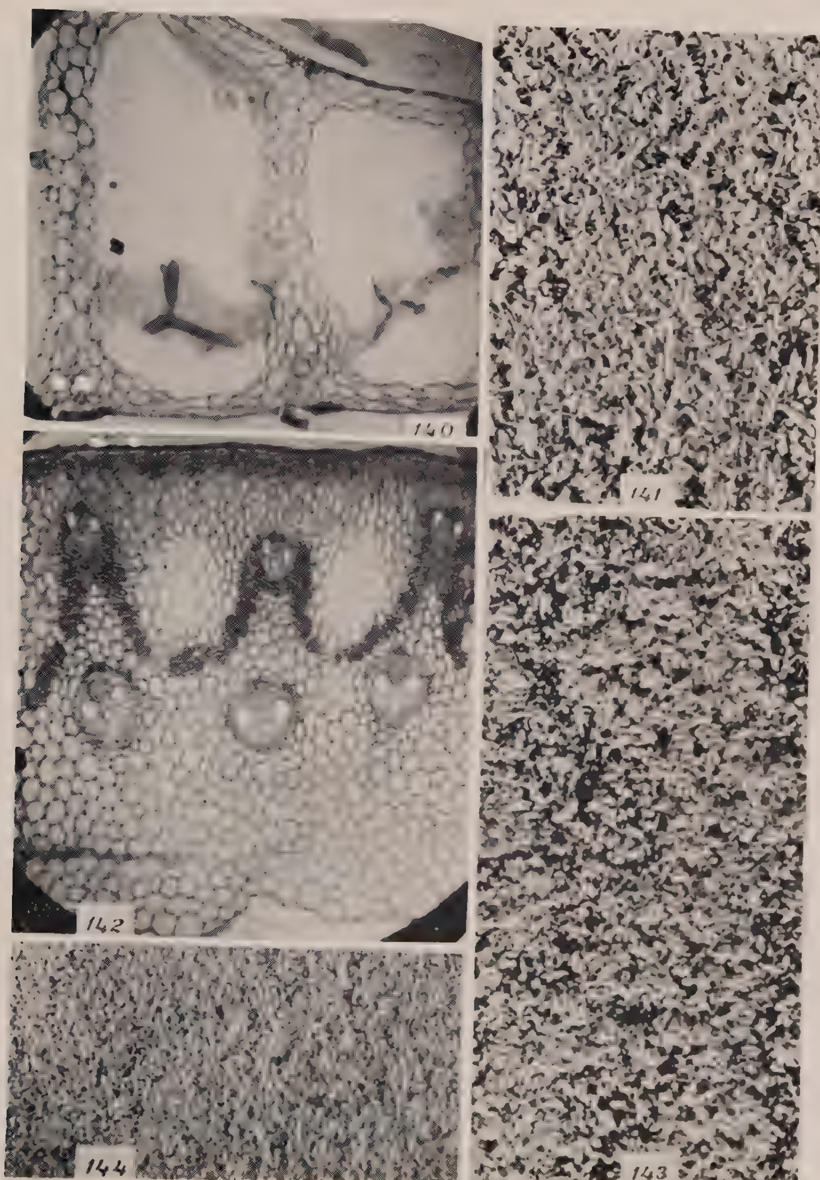
PLATE 19



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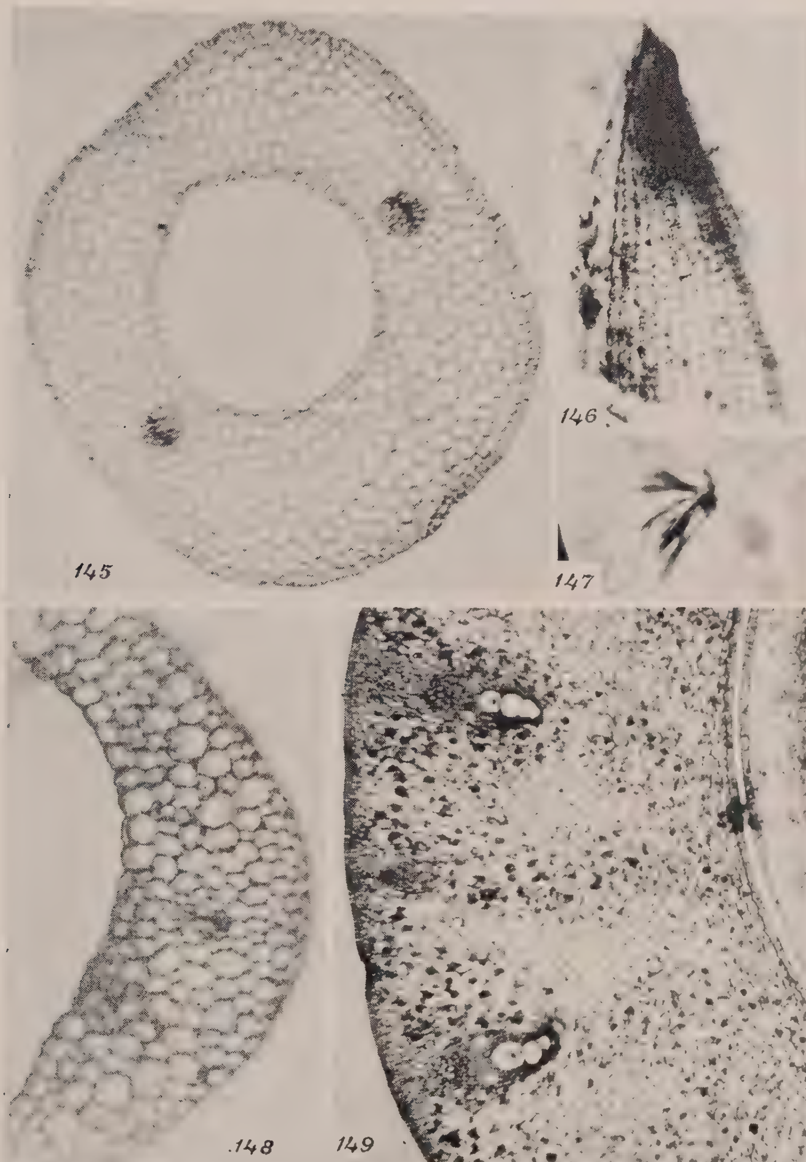

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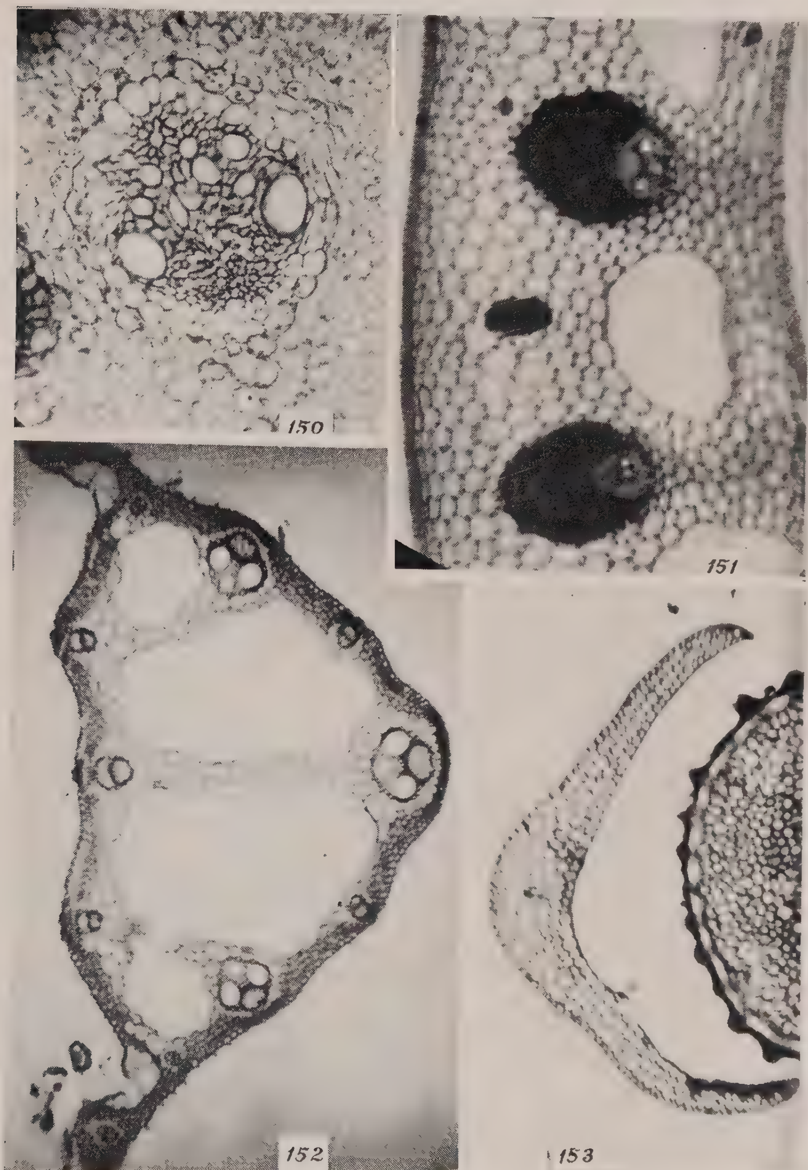

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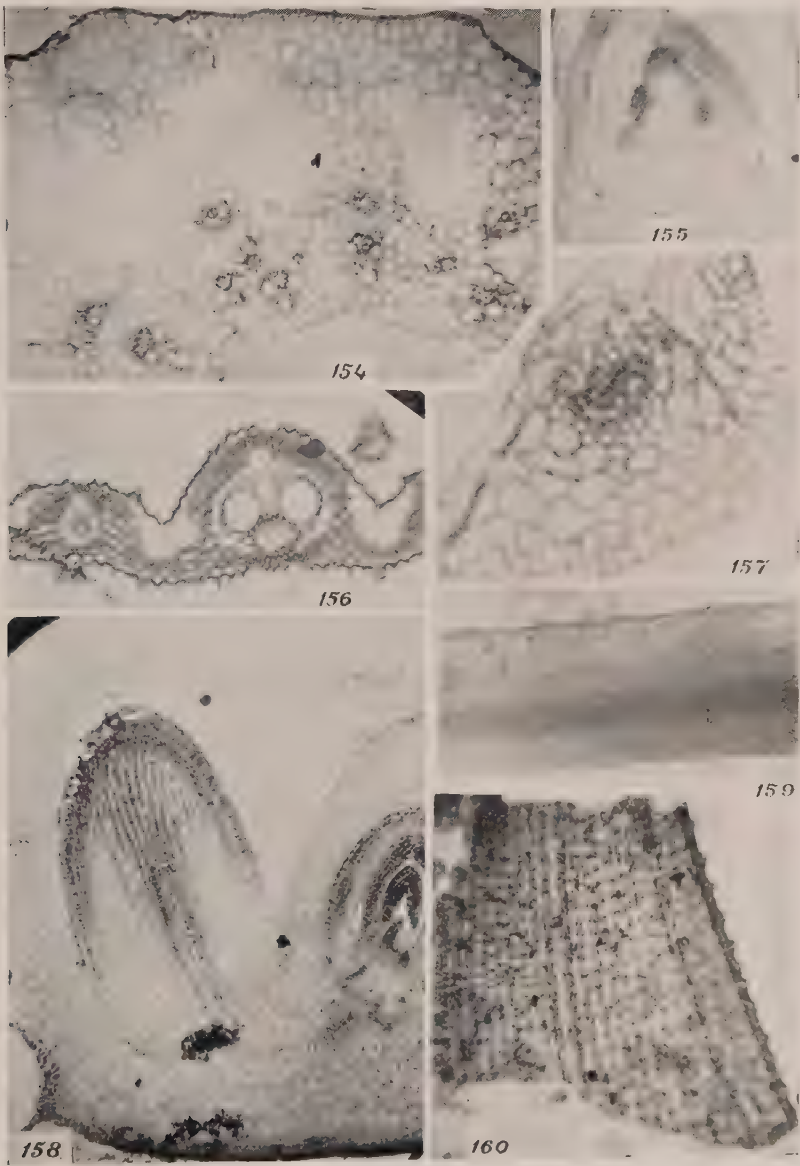

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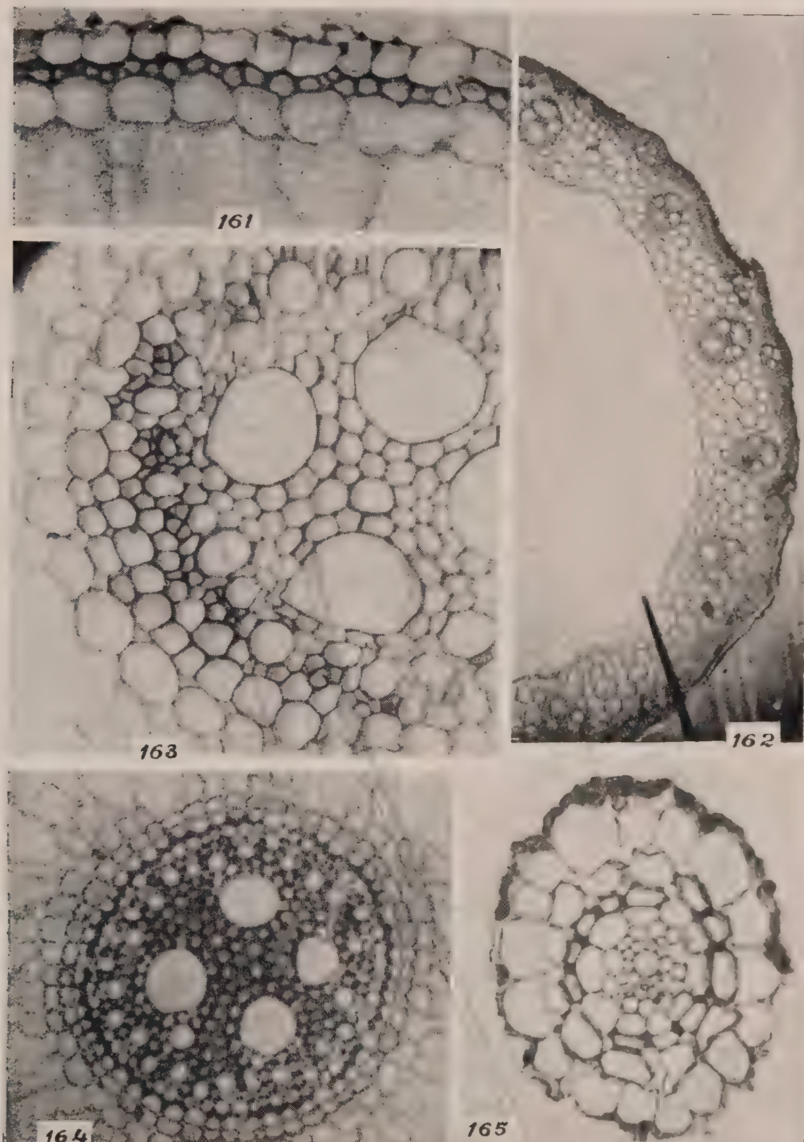

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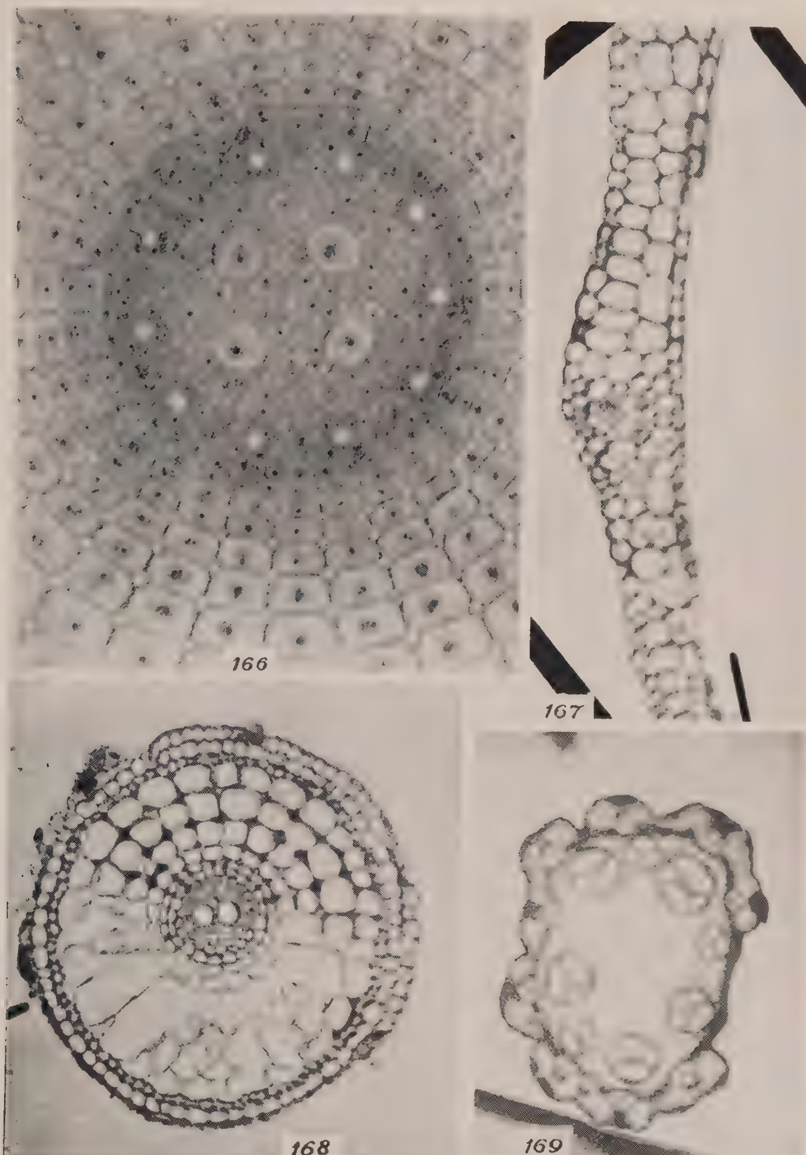

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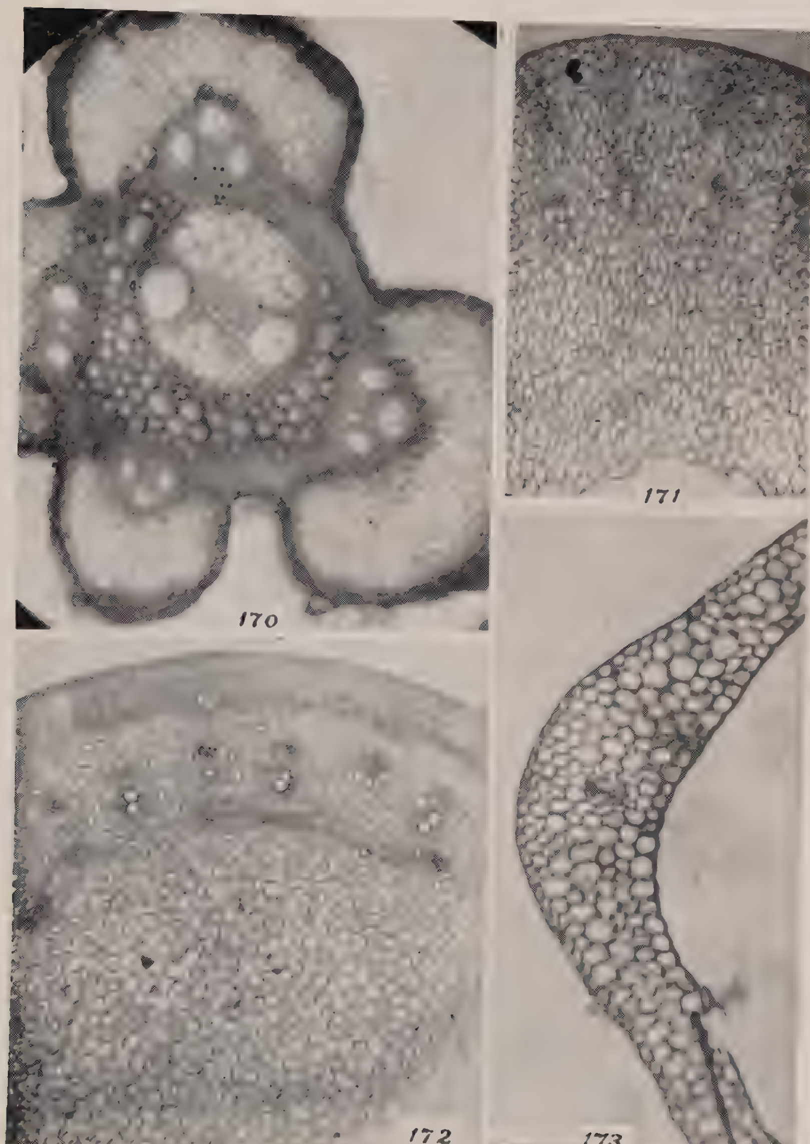

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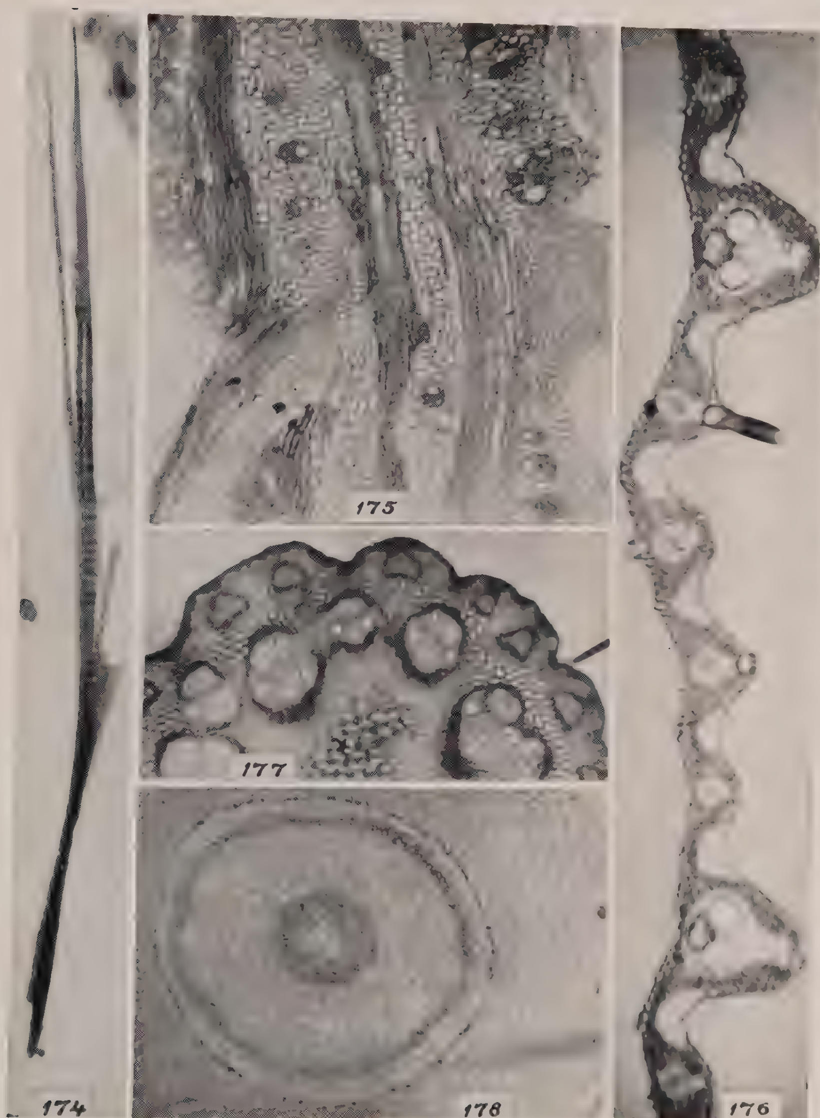

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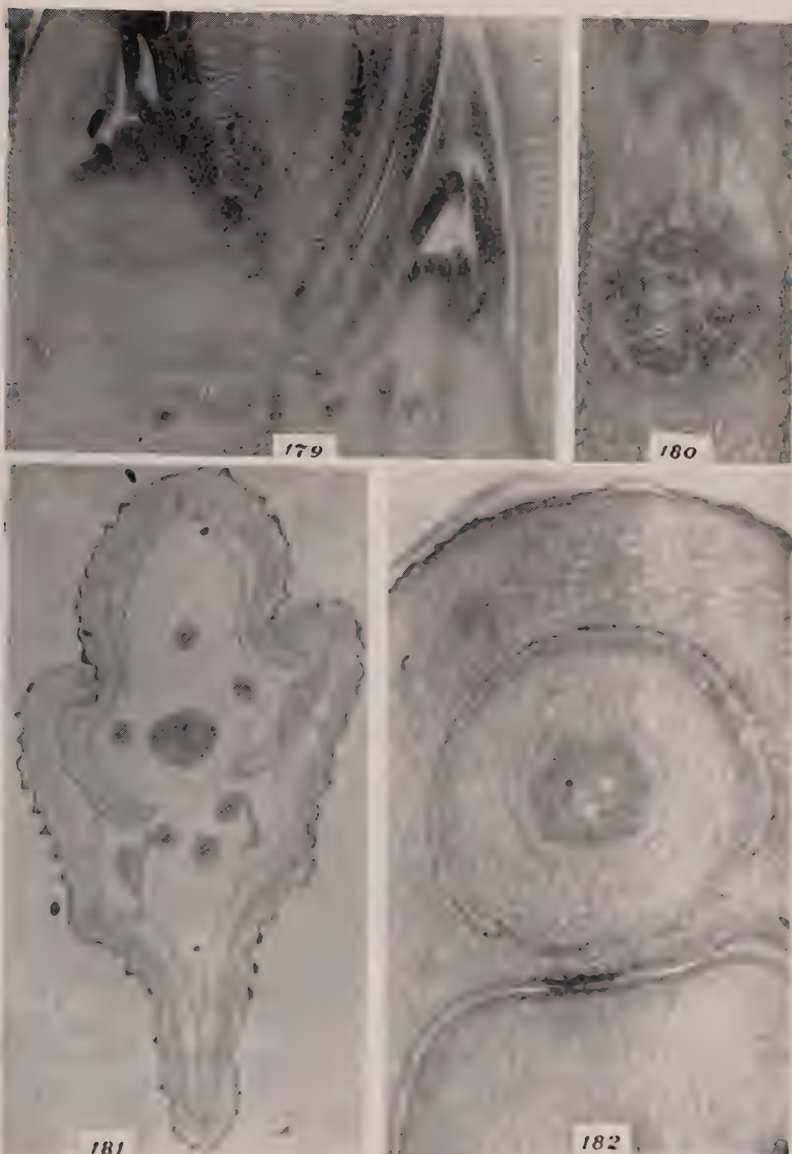

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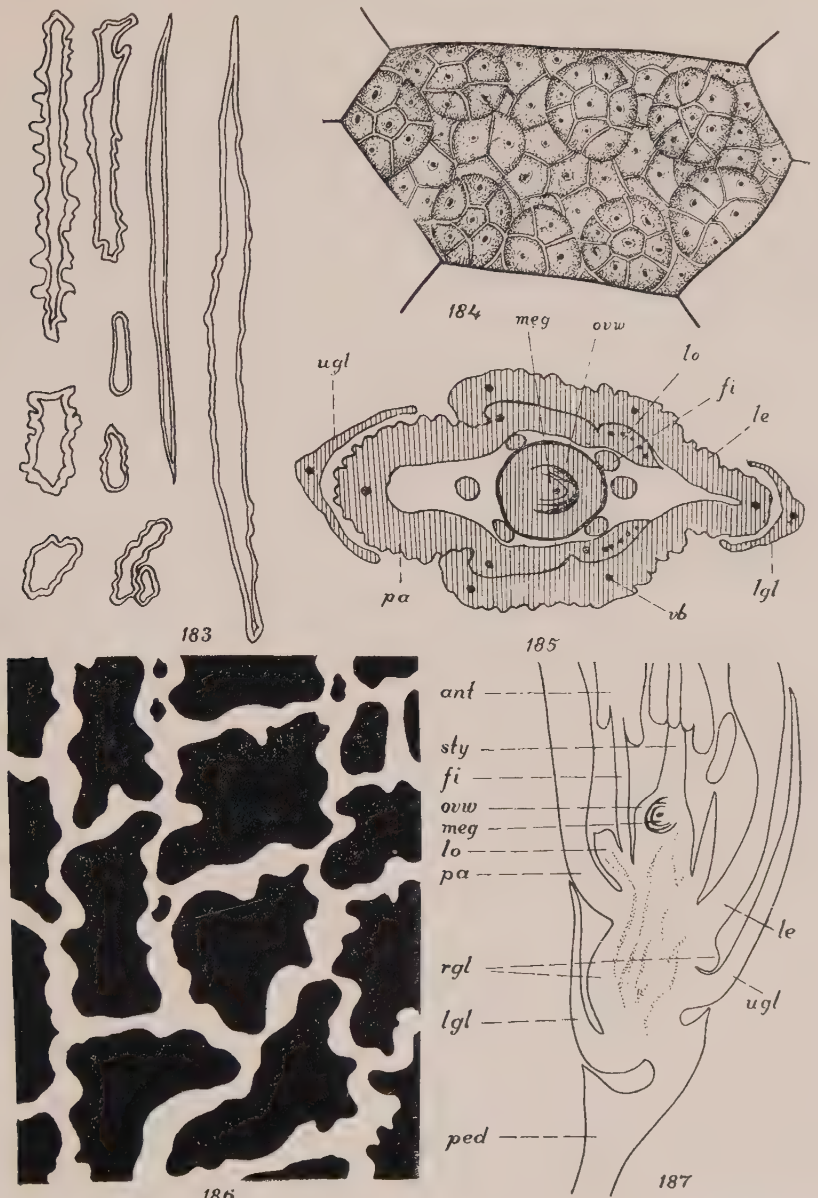
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PLATE 29

COLLEGE AND ALUMNI NOTES

The following candidates received their degrees in agriculture at the annual commencement exercises of the University of the Philippines on March 23: *Bachelor of Science in Agriculture*—Pablo B. Agcanas, Virgilio T. Almeda, Domingo M. Altamirano, Lorenzo M. Ancheta, Alfredo C. Cabbab, Andres C. Caranto, José V. Castillo, Lino I. Chatto, Amando M. Dalisay, Conrado C. Dinulos, Romeo C. Espino, Ruperto C. Evangelista, Celerino G. Gariando, Romulo B. Gines, Vicente G. Guillem, Fortunato A. de Guzman, Jr., José M. Ilagan, Pacifico G. Jimenez, José G. Luna, Miguel Manresa, Jr., Demetrio G. Miranda, Francisco G. Montinola, Celestino B. Quilang, Ramon C. Quilapio, Victoriano G. Rivera, Gavino B. Rotor, Jr., José F. Silva, Filemon D. Tayamen, Doroteo F. Tinio, Isidro C. Villa, and Ramon P. Yanga, Jr. *Bachelor of Science in Sugar Technology*—Basilio M. Balasico, José K. Demeterio, and Marcial V. Enriquez. *Certificate in Agricultural Education*—Crispin R. Las Marias, B.S.A.; Leoncio Meneses, B.S.A.; Ernesto L. Rigor, B.S.A.; and Felix N. Salcedo, B.S.A.

The Joaquin J. Gonzalez Medal, which is awarded to the graduating student obtaining the highest academic average during the entire course, was granted to Amando M. Dalisay and José K. Demeterio. The donor very generously granted two medals, instead of only one, as had been the practice in previous years, on account of the extreme closeness in the averages of the two candidates, which rendered it difficult to make but a single award.

At the last two meetings of the Los Baños Biological Club, the following papers were read:

February 18, 1937

Dr. N. Galvez. On the physical and chemical properties of white soil in Mount Maquiling.

Dr. F. O. Santos. Studies on the plane of nutrition of families of laborers in Calabanga, Camarines Sur.

Dr. V. C. Calma. Variety tests of sugar cane.

March 4, 1937

Mr. Julian Banzon. A method of resinifying vegetable oils.

Dr. L. G. Gonzalez. Progress in plant propagation research in the College of Agriculture.

The Society for the Advancement of Research elected as its officers for 1937-1938 Dr. F. M. Fronda, president, Dr. A. L. Teodoro, vice-president, Dr. J. B. Juliano, secretary, and Dr. L. G. Gonzalez, treasurer. Likewise, at the Los Baños Biological Club, the new incumbents are Dr. Dionisio I. Aquino, president, and Prof. V. Sajor, secretary.

Prof. F. B. Morrison, head of the Department of Animal Husbandry, Cornell University, was guest of honor at the initiation ceremonies of the Society for the Advancement of Research on March 10, 1937, at the College Auditorium, where he spoke on the new trends in animal nutrition. The program opened with a paper by Dr. Miguel Manresa, president of the SAR, on the influence of temperature on the various breeds of cattle. The initiates to active membership were: Dr. C. G. Manuel (by affiliation, as member of the Sigma Xi, Michigan chapter) and Dr. Felipe M. Salvoza (by election).

Director Hilarion S. Silayan, '17, of the Bureau of Plant Industry, was the guest of honor at the sixth commencement exercises of the U. P. Rural High School on March 20, in which thirteen students were graduated. Director Silayan dwelt in his speech on the necessity for a closer coöperation between the College and his Bureau.

Dean B. M. Gonzalez was the commencement speaker at Batangas High School on March 8 and at the Luis Palad High School (Tayabas) on March 22.

With the approval of the University authorities, the Secretary of Agriculture and Commerce appointed as technical collaborators of the Bureau of Forestry Doctors N. B. Mendiola, L. B. Uichanco, G. O. Ocfemia, A. L. Teodoro, and L. G. Gonzalez.

Dr. Gerardo O. Ocfemia, head of the Department of Plant Pathology, was recently appointed member of the committee on diseases of the sugar cane of the International Society of Sugar Technologists, which will hold its sixth congress in Baton Rouge, Louisiana, in 1938.

Prof. Nicolas Zafra, of the College of Liberal Arts, read a paper on University rules on attendance at the faculty conference for the improvement of teaching which was held at the College of Agriculture on February 15.

ECONOMIC REALITIES [1]

There are momentous problems confronting this country, and any country for that matter, in the solution of which the political scientist and the economist occupy joint territory. Philippine trade relations during and after the Commonwealth period is a case in point. Quite often, purely economic considerations may run counter to what may be wise governmental policy. The general issue between protection and free trade in many countries illustrates only too well this divergence of policies. It seems futile, therefore, to argue about the proper duration of the period of preparation prior to political independence. Variance of opinion is, in the last analysis, only a difference in points of view.

There are certain realities which any student of economics cannot ignore. During the last three decades of American sovereignty, Philippine agricultural exports have expanded tremendously by virtue of the sheltered position that this country has enjoyed within the American tariff wall. The sugar industry illustrates best our economic dilemma. This industry has grown to such abnormal proportion that it has constituted in recent years nearly two thirds of the country's exports. But this expansion has been artificial for, when one considers its economic position, one sees that its present state of apparent progress solely depends upon the tariff advantage it enjoys in the great American market. Without this advantage, Philippine sugar cannot be marketed anywhere on a competitive basis. And worse, when one views the world sugar situation, with every country or political unit bending all efforts at self-sufficiency, it is found that sugar has ceased to be a major article of international commerce.

What, then, of our sugar and other agricultural industries after the closing of the American free market? An unbalanced and unstable economy would result. It is true that in the long run economic forces, if left free to operate unhampered, will tend to correct this state of economic disequilibrium. But economic forces have a way of operating so slowly and at times so ruthlessly that men of action irk with impatience at the slow and painful results. From purely economic considerations, therefore, any abrupt change of present trade arrangements will work havoc upon our artificially stimulated indus-

[1] General contribution from the College of Agriculture No. 564.

tries. A period of preparation as embodied in our independence law is a concession to this view in the belief that by applying gradually the rigors of American protective policies some adjustment with the least attendant evils might be made possible within the period fixed by statute.

On the other hand, the point of view of the political scientist appears unassailable. It has been demonstrated that the Philippines under the operation of the independence law has been shorn of vital powers considered necessary to help solve its multifarious problems. And worse, unfavorable Congressional legislation tends to impair or nullify the provisions of that law. Hence, the demand for the termination or shortening of this anomalous political relation.

Some happy medium has, therefore, to be found which might harmonize the economic and political viewpoints. The situation is not without hope for the President's proposals to Washington suggest a formula for ending an anomalous political relation and at the same time make possible a period for adjusting our national economy to an independent national existence.

Weighty is the responsibility, therefore, of the Philippine representation in the joint preparatory Committee of experts now sitting at Washington to consider American-Philippine trade relations.

JOSÉ E. VELMONTE
Of the Department of Agricultural Economics

J. B. Banzon
A Pleistocene derelict: aboriginal Negrito in Bataan province, Luzon

A CYTOLOGICAL AND MORPHOGENETIC STUDY OF SOME PINEAPPLE VARIETIES AND THEIR MUTANT AND HYBRID DERIVATIVES [1]

J. M. CAPINPIN AND GAVINO B. ROTOR, JR.
Of the Department of Agronomy

WITH THREE PLATES

The pineapple breeding work conducted in the College of Agriculture (Mendiola, 1926; Capinpin, 1935) has resulted in the development of several desirable forms of pineapple. These improved pineapples have been developed empirically by varietal hybridization and selection. It is believed that a knowledge of chromosomal constitution of the parental clons used in breeding would help interpret certain phenomena observed before and after crossing. This investigation was therefore carried on as an attempt to apply cytological inquiry in pineapples raised and developed in the Philippines.

Previous cytological researches on the genus Ananas

A survey of the literature indicates that the earliest cytological work on pineaple was undertaken in Sweden by Heilborn (1921) who reported a count of 75 chromosomes from two pineapple races collected in Ecuador. This number was interpreted as neither a normal somatic nor polyploid condition, for the diploid number was then unknown.

Collins and Kerns (1930) made a preliminary study of the chromosome number and meiosis in seven pineapple varieties grown in Hawaii and a wild type from Brazil, and concluded that the diploid number of this species is 50. They moreover found that reduction is normal with a consequent and regular formation of gametes containing 25 chromosomes. Aside from the diploid count of 50 chromosomes, triploidy was observed by Collins and Kerns (1931) and Collins (1933) to occur in some wild species and in some commercial varieties and variety hybrids.

Heilborn (1921) claimed that the Ecuador races of pineapple might be a polyploid hybrid between two other races with 30 and 45

[1] Part of the material included in this paper was taken from the thesis presented by the junior author for graduation, 1937, with the degree of Bachelor of Science in Agriculture, University of the Philippines, No. 1092. Experiment Station contribution No. 1176. Received for publication, April 23, 1937.

as haploid chromosome numbers. He further inferred that the fundamental number of the genus is probably 15 or 5.

On the other hand, Collins and his associates (1930, 1931, 1933) consistently reported 25 as the fundamental haploid or gametic number of the genus. It is thus evident from these earlier investigations that different races of the genus *Ananas* might be of different cytological constitutions, and further investigation might reveal among other races, such as those grown and developed in the Philippines, a series or condition of polyploidy.

Objects of the work

This investigation included the following objects: (*a*) to make a chromosome study of pineapple varieties and their hybrids, (*b*) to record any pineapple types with deviating chromosome numbers, and (*c*) to correlate as much as possible cytological condition and morphological characteristics in pineapple.

The work was begun in the early part of November, 1935 and ended in April, 1937. The cytological investigation was done in the Plant Breeding laboratory of the Department of Agronomy, College of Agriculture, Laguna, P. I.

Pineapple varieties used

The pineapple varieties, mutants, and their resultant hybrids, all produced by the Plant Breeding Division of this College, were used to supply materials for chromosome studies. These pineapple forms and their brief description, recorded in the Plant Breeding record book No. 25 of the Department of Agronomy, are as follows:

(1) Clon No. 14—(Red Spanish × Smooth Cayenne) F_1, spineless.
(2) Mutant of Clon No. 14—This mutant observed by Mr. Toribio Mercado, of the Agronomy Department, is spiny, in contrast with spineless parent clon No. 14.
(3) Clon No. 17—(Red Spanish × Smooth Cayenne) F_1, spineless.
(4) Clon No. 23—(Red Spanish × Smooth Cayenne) F_1, spiny.
(5) Clon No. 28—(Red Spanish × Smooth Cayenne) F_1, spineless.
(6) Clon No. 386—(Smooth Cayenne × Red Spanish) F_1, spineless.
(7) Clon No. 457—(Smooth Cayenne × Red Spanish) F_1, spineless.
(8) Clon No. 581—(Smooth Cayenne × Red Spanish) F_1, spineless.
(9) Clon No. 729—(Smooth Cayenne × Buitenzorg) F_1, spiny.
(10) Clon No. 772—(Smooth Cayenne × Buitenzorg) F_1, spineless.
(11) Clon No. 865—(Queen × Clon No. 28) F_1, spiny.
(12) Clon No. 944—(Queen × Clon No. 28) F_1, spiny.
(13) Clon No. 996—(Queen × Smooth Cayenne) F_1, spiny.
(14) Clon No. 1044—(Smooth Cayenne × Variegata) F_1, spineless.
(15) Red Spanish—the so-called native, spiny pineapple.

(16) Smooth Cayenne—the so-called Hawaii, spineless pineapple.
(17) Buitenzorg (Bogor)—spiny, sweet, small-fruited pineapple introduced from Java by Dr. N. B. Mendiola.
(18) Variegata—Ornamental pineapple mutant originally discovered by Doctor Mendiola.

All of the foregoing pineapple varieties are grown in the Plant Breeding garden. Crowns and slips of these varieties grown in the field were allowed to root in a propagation bed of the Plant Breeding Nursery. Root tips from the roots of these slips and crowns were the materials used for the determination of somatic chromosomes.

Flower buds were obtained from the plants in the field. The pollen mother cells furnished the materials for the study of gametogenesis and meiotic characteristics of the pineapple.

Cytological technique

Two cytological methods of investigation were used in the study of the chromosomes.

Paraffin section. This method was employed in studying reduction division, or meiosis, in the young pollen cells and in recording somatic count of chromosomes in the root tips. The P. F. A. 15 formula of picro-formal-acetic mixture used by Capinpin (1933) was found to give good fixation and furnish excellent slides and clear figures of chromosomes in both meiotic and somatic mitoses. The formula is:

Picric acid sat. aq. sol	75	cc.
Formalin (commercial, 40%)	25	cc.
Glacial acetic acid	5	cc.
Urea	2	gm.
Chromic acid	1.5	gm.

In this mixture, urea and chromic acid were added just prior to fixation. The root tips and anthers were collected during the warmer part of the day, between 9:00 a. m. and 12:00 noon. The root tips of slips and crowns of a given pineapple clon were obtained by allowing them to root in sphagnum moss and thoroughly cleaning them before fixing. The anthers were obtained from the individual flowers or eyes of a fruit head. By a series of trials, it was finally determined that the best age of the flower bud which gives mitotic figures was the stage when the purple tip of the corolla was about to emerge. This corresponds to the third stage of floral development in pineapple according to Capinpin and Mercado[2] Both the

[2] Capinpin, J. M., and T. Mercado. Pineapple Breeding in the College of Agriculture. (Paper read before the Los Baños Biological Club, March 15, 1928. Unpublished.)

root tips and anthers were fixed for 24 hours, rinsed slightly with water, dehydrated through grades of alcohol, cleared in several series of xylene, embedded in paraffin, and stained with Heidenhain's iron-alum haematoxylin. Microtome sections were cut to a thickness of 10 to 12 microns.

Smear preparations. The earlier investigators on pineapple cytology have failed to see chromosomes by the use of iron-acetocarmine preparations. The writers, however, employed the procedure with smear preparations which Capinpin (1930) found suitable for *Oenothera* buds and obtained satisfactory and clearly visible figures of chromosomes. This method may be briefly outlined as follows: anthers were clipped off and arranged side by side on a slide; a second slide was placed crosswise over this, and with just enough strength to extrude the pollen mother cells, this was squeezed circularly. The slides with pollen smears were then placed on a dish containing fixing solutions A and B mixed in equal amounts. The constituents of this fixative were as follows:

Solution A

Chromic acid	5 gm.
Glacial acetic acid	50 cc.
Water	320 cc.

Solution B

Formalin	100 cc.
Water	275 cc.

Fixation in this solution lasted for six hours. After running through different grades of alcohol, the materials were mordanted with iron-alum in 70 per cent alcohol and stained with one-half per cent brazilin in 70 per cent alcohol. The whole preparations mounted in balsam were as permanent as the paraffin sections.

Cytological illustrations

The cytological figures presented in this paper were drawn with Bausch and Lomb camera lucida at table level by means of a Bausch and Lomb microscope with apochromatic objective 1.9 mm. (N. A. 1.30) in combination with compensating oculars 10× and 20×. The approximate magnification of the camera lucida drawings is 1800 with the 10× ocular and 3600 with the 20× ocular.

The microphotographs of chromosome configurations were taken by the senior author with a Bausch and Lomb microphotographic apparatus on a Bausch and Lomb microscope with 4 mm. (N.A. 0.65) and 1.9 mm. (N.A. 1.30) apochromatic oil immersion objective, and 10× and 20× oculars.

CYTOLOGICAL INVESTIGATIONS AND RESULTS

Chromosome number of College pineapple clons and derivatives

In determining and recording the chromosome number characteristic of each pineapple clon, only the microscopical preparations showing clearly visible chromosome configurations in both root tips and pollen mother cells were considered. This necessitated microscopical examination of hundreds of slide preparations and discarding slides wherein differentiation of chromosomes and cell plate owing to deep or light staining was not very sharp.

The chromosomes of mitotic figures in root tips were counted at the somatic metaphase plate. Those in the pollen cells were determined at the lateral or polar view of heterotypic or first metaphase. In this way, the root tip determinations represented the somatic count, and the pollen cell counts, representing bivalents or chromosome pairs, refer to gametic or haploid chromosome number. The results of this determination are given in the following table:

TABLE 1

Chromosome number of pineapple varieties and their hybrid and mutant derivatives

CLON	BRIEF DESCRIPTION	CHROMOSOME NUMBER	
		gametic	somatic
		n	$2n$
No. 14	(Red Spanish × Smooth Cayenne) F_1	—	60
Mutant, No. 14	Mutant of Clon No. 14	—	50
No. 17	(Red Spanish × Smooth Cayenne) F_1	—	50
No. 23	(Red Spanish × Smooth Cayenne) F_1	—	50
No. 28	(Red Spanish × Smooth Cayenne) F_1	—	50
No. 386	(Smooth Cayenne × Red Spanish) F_1	25	—
No. 457	(Smooth Cayenne × Red Spanish) F_1	25	—
No. 581	(Smooth Cayenne × Red Spanish) F_1	25	—
No. 729	(Smooth Cayenne × Buitenzorg) F_1	25	—
No. 772	(Smooth Cayenne × Buitenzorg) F_1	—	50
No. 865	(Smooth Cayenne × Buitenzorg) F_1	25	—
No. 944	(Queen × No. 28) F_1	25	—
No. 996	(Queen × Smooth Cayenne) F_1	25	—
No. 1044	(Smooth Cayenne × Variegata) F_1	25	—
Red Spanish	Ordinary native pineapple	—	50
Smooth Cayenne	Hawaiian variety	—	75
Buitenzorg	Introduction from Java	—	50
Variegata	Ornamental bud mutant	—	50

The chromosomes of pineapple in both root tip cells (see Plate 1, figs. 1 to 10) and pollen mother cells (see Plate 2, figs. 10 and 11) were found to be very small and almost spherical. These chromo-

some configurations persist at the equatorial plates of the spindles, both in the somatic and meiotic mitoses of root tip and pollen cells, respectively. In the latter, the chromosomes form in pairs or appear as bivalents; they are generally dumb-bell shaped (see Plate 2, fig. 12). The chromosome number of pineapple clons under investigation established the fundamental haploid or gametic number as 25, and the somatic or diploid number as 50. On this basis, the clons which gave counts of 60 and 75 chromosomes would represent chromosomal variants. The 60-chromosome type would then be a heteroploid form containing 10 extra chromosomes, in addition to the normal characteristic number of 50. This heteroploid form may be represented as $2n + 10$, indicating a change in chromosome number in five pairs, or an extra ten individual chromosomes. On the other hand, the 75 chromosome type definitely represents a polyploid with a change in chromosome number of all sets or chromosome parts. Since 25 is the established gametic or haploid (n) number of pineapple chromosomes, the clon having 75 chromosomes here reported would represent the $3n$ or triploid form. As no critical study was attempted in the chromosome morphology of pineapples, the identification of the extra sets or chromosome complements of both the heteroploid and triploid forms cannot very well be discussed. Of the eighteen clons studied, sixteen representing established varieties, hybrid and mutant derivatives gave a diploid count of 50 chromosomes; one clon of hybrid origin was a heteroploid or trisomic form with 60 chromosomes, and a commercial variety proved to be a triploid with 75 chromosomes. The cytological basis of the possible appearance of the chromosomal types here observed will be referred to later after accounts on microsporogenesis and other phases of meiosis are given.

Microsporogenesis and chromosomes at meiosis

Some pertinent observations on the cellular and nuclear processes in the pollen mother cells of pineapple anthers are here given as an account of gametogenesis in this species. At resting stage, the young pollen mother cells arrange themselves closely and are seemingly crowded with one another in the loculus of the anther. The shape is not definite; some are polygonal, others more or less rounded. These rows of young pollen mother cells are bounded by a layer or two of tapetal cells which furnish nourishment to the former. The young sporocytes are filled with a large amount of cytoplasm and a single nucleus. The nucleus has one nucleolus, but there are nuclei with two nucleoli (Plate 2, fig. 1). At the prophase stages (Plate

2, figs. 2, 3, 4, and 5), the nuclear network or reticulum is resolved into long slender threads forming the prophase spireme. As far as could be ascertained, these chromatic threads seemed to be continuous. The nucleolus loses its definite orientation and sometimes places itself at the border of nuclear membrane and at other times occupies the center of the nucleus. Shortly after the formation of spireme, the chromatic threads seemed to have shortened and thickened considerably and to have been drawn into a tight dense mass (Plate 2, fig. 6). The whole nuclear structures lie irregular, while the presence of chromatic bodies scattered irregularly near the nuclear membrane was evident. The next stage that follows appears to be accompanied by a shortening and condensation of the nuclear threads, resolving themselves into visible nuclear bodies, or rods, the chromosomes. This stage of diakinesis (Plate 2, figs. 7 to 9) presented the appearance of chromosomes which may or may not be in a well-oriented manner. The nuclear membrane then disappears, and fibers appear forming the spindle figures of the first or heterotypic metaphase (Plate 2, fig. 12, Plate 3, figs. 1, 2, and 3). In this first stage of meiosis, the chromosomes of the diploid form (50 chromosomes) assumed regular dumb-bell-shaped bodies, in forming pairs cr bivalents (Plate 2, fig. 12). In the diploid types, chromosome conjugation is regular; the formation of 25 bivalents is the rule. Numerous counts of heterotypic metaphases in the diploid types always give a regular distribution of 25 chromosomes going to one pole and 25 going to another pole, which means that the formation of gametes containing 25 chromosomes is a regular feature in the gametogenesis of pineapple. The meiotic regularity of the chromosomes of our diploid pineapple clons is further substantiated by the absence of lagging chromosomes at the first anaphase and telophase stages shown in Plate 2, figs. 13, 14, and 15. The second mitosis or the homotypic division of chromosomes, in general, was also observed to be normal. In Plate 2, fig. 16, and in Plate 3, fig. 4, is clearly pictured a cell in homotypic mitosis, wherein the chromosomes can be seen in polar and lateral views of the metaphasic spindles. The cell in fig. 17, Plate 2, shows also a homotypic metaphase, the chromosomes of which were scattered throughout the cell plate. The anaphase and telophase stages are then regularly followed by interkinesis. As a whole, meiotic divisions in the diploid type are carried to completion, and mostly normal pollen tetrad stages are formed (Plate 2, fig. 18).

GENERAL DISCUSSION

The establishment of the diploid or somatic chromosome number as 50 in the pineapple clons here investigated, as well as the regular behavior of meiosis in these diploid forms, is of utmost significance in view of conflicting interpretations of earlier investigators on pineapple cytology. Heilborn's (1921) reported count of 75 chromosomes was not interpreted as a diploid or haploid count. He assumed that the fundamental gametic number might be 15 or 5. It is apparent that his 75-chromosome determination from pineapple races of Ecuador corresponds to a triploid case found in this investigation. In the present investigation, this 75-chromosome clon is a polyploid form with 3 sets of chromosomes or a condition of triploidy. This interpretation is in conformity to the findings of Collins and Kerns (1931) and Collins (1933), who reported the occurrence of triploid pineapples among F_1 hybrid population produced by crossing Cayenne and a wild species from Brazil. In their subsequent studies, the West Indies variety, Cabezona, was found to contain 75 chromosomes. In the present investigation, the clon of variety Smooth Cayenne, the naturally seedless type of pineapple, proved to be triploid containing 75 chromosomes in the somatic tissue.

A similar chromosonal variant of Cayenne containing 1½ times as many chromosomes as a normal Cayenne was reported by Kerns (1931). The prevalence of self-sterility and partial or total absence of seeds in Cayenne pineapple appears to be a consequent manifestation of triploidy, a condition similarly met with among other spermatophytes. The pollen grains of the triploid individual are mostly shrivelled, and the majority are sterile and empty (Plate 3, fig. 6). Pollen of normal pineapple plant shows uniform grain size and development and absence of empty grains (Plate 3, fig. 5). This condition of triploidy in Smooth Cayenne can still be verified by results obtained on actual crossing experiments performed by the Plant Breeding staff of the College of Agriculture.

The discovery in the present investigations of the existence of pineapple clons with diploid (50), heteroploid (60), and triploid (75) chromosome numbers is important in connection with pineapple breeding since it opens up definite possibilities of forming new combinations of chromosomes and, as a result, new character combinations in the pineapple plants. The origin of the chromosomal types appears to be traceable to the egg gametes, rather than sperm gametes, for it has been shown that reduction division, or meiosis, in pollen mother cells in general is regular. Collins (1933) was also of

the opinion that triploidy arose from unreduced egg gametes being fertilized by normal haploid pollen. According to this view, a normal diploid pineapple with 50 chromosomes may form an egg with 50 chromosomes, and, when fertilized by normal haploid pollen with 25 chromosomes, results in the formation of a zygote with 75 chromosomes. The unreduced number of chromosomes in the egg may be the result of omission of second mitosis in meiotic division or merely to a "mutated" germ cell, as pointed out by Capinpin (1933).

Collins' (1933) conclusion as to the probable occurrence of this phenomenon was based upon genetic and morphological evidence to which the writers fully subscribe. As regards the appearance of heteroploid with 60 chromosomes, two views may be expressed for possible explanation. This particular clon may either be the progeny of a cross between two diploid varieties or one of the resultant chromosomal types from a cross between a diploid female variety, Red Spanish, and a triploid male parent, Smooth Cayenne. If the parental varieties are both diploid ($2n=50$) the formation of egg gametes with chromosome number other than the normal haploid number of 25 may be conceived. It will be recalled that in pollen cells, the chromosome distribution is normal and gametes with 25 chromosomes are the regular products of reduction division. In megasporogenesis, it is quite possible that gametes containing 35 chromosomes are produced. These ovules with 35 chromosomes fertilized with pollen gamete containing 25 chromosomes lead to the formation of zygote with 60 chromosomes. This cytological behavior giving rise to a range of permutations in the chromosome distribution of egg cells, while mostly inferred, appears to occur naturally in view of the existence of several polyploid forms among pineaple races grown in different countries. On the other hand, if it is assumed that the male parent, the Smooth Cayenne, is triploid, then the heteroploid form with 60 chromosomes would merely be the usual result of fusion between an egg with normal haploid number of 25 chromosomes and a male gamete with 35 chromosomes. The formation of 35-chromosome gamete from a triploid containing 75 chromosomes may be considered one of the several classes of male gametes which an unbalanced polyploid, like triploid, would produce on normal germ-cell formation (Capinpin, 1933). This assumption appears to be feasible in view of the findings that triploidy occurs among Smooth Cayenne clons and that in the series of crosses made between Red Spanish and Smooth Cayenne, the first-generation hybrid clons differ phenotypically.

The heteroploid Clon No. 14 with 60 chromosomes, which may be expressed as (2n + 10) chromosome complex, giving rise to a mutant form with 50 chromosomes, may be cited as a case of somatic segregation resulting in a loss of 10 chromosomes in the parent clon. Clon No. 14 is one of the selected hybrids which is now grown commercially. The mutation observed refers to the presence of spines in the crown of the parent Clon No. 14, which is wholly spineless. The mutational appearance through vegetative means, especially in the case of chromosomal change, has been found to be true in several cases of somatic segregation, where chromosomes during somatic mitosis may lag or fail to reach the corresponding spindle pole, giving rise to resulting daughter cells of unequal chromosome numbers. The varietal clons, Buitenzorg (Bogor) and Red Spanish, are ordinarily diploid and their resultant hybrids proved to be normally diploid, containing 25 as gametic count and 50 as the somatic count. This furnishes confirmation of the writers' opinion that the fundamental haploid number for the genus *Ananas* is likely to be 25. Smooth Cayenne pineapple is also diploid, although the clon reported in this paper proved to be triploid. This chromosomal constitution of various F_1 varietal hybrid combinations constitute genetic evidence as to the regular meiosis of pineapple ovule and pollen cells. The Variegata pineapple, supposed to have arisen from a clon similar to Red Spanish, also contains a diploid count of 50 chromosomes. Again the appearance of this ornamental mutant does not involve any chromosomal change as cytological evidence in the present studies show but rather in plastid or cytoplasmic nature. The variegation of this mutant readily disappears on sexual propagation, but persists in clonal progeny.

The cytological phenomena exhibited by the genus *Ananas* include chromosome doubling in the egg cells of the pineapple as reported by Collins (1933) and the existence of heteroploidy and triploidy as discovered in the present investigations. These phenomena have implications of the greatest significance for pineapple breeding. As regards chromosome doubling, Collins (1933) concludes that "this phenomenon makes it possible to retain all the characters of a good heterozygous variety and to add to them some of the characters of other varieties and species through hybridization and consequent formation of triploids".

With reference to the utilization of polyploid characteristics in the College pineapple clons, it would be interesting to study the progeny resulting from a cross between a triploid Cayenne and a he-

teroploid Clon No. 14. A triploid pineapple shows delayed maturity, vegetative luxuriance, partial or total absence of seeds, and partial or complete sterility. In this cross, the triploid would be used as the female parent, for triploid pollen (see Plate 3, fig. 6) is generally empty, and the heteroploid clon having 60 chromosomes, the pollinator. Various biotypes and possibly tetraploid forms may appear in triploid offsprings as reported by Capinpin (1933). Aside from the possible appearance of tetraploidy, the segregation into various chromosomal types should offer interesting types of variation as materials for selection. Tetraploidy, or the doubling of the diploid number of chromosomes in a species, is related to gigantism, and so far has not been reported in the genus *Ananas*. It may be mentioned at this juncture that "many of the most important modern improvements in cultivated plants are due to polyploidy". On account of their inability to breed true, triploids and other unbalanced or odd-numbered polyploids are naturally confined in fruit or flowering plants that are propagated vegetatively to which category the genus *Ananas* belongs. It is now recognized that triploids, tetraploids, pentaploids and even hexaploids among horticultural crops have by asexual propagation gained for themselves sufficient distribution to be reckoned as distinct varieties or races.

SUMMARY AND CONCLUSIONS

The present investigation is the first study conducted in the Philippines on the cytology of *Ananas*. From results obtained, the following conclusions are drawn:

1. The fundamental haploid number based on established varieties, mutants, and hybrids of pineapple was found to be 25 chromosomes as revealed by the pollen cells, and the diploid number was established to be 50 chromosomes as indicated in the root-tip cells. The pineapple chromosomes are small and spherical.

2. The diploid pineapples are: Mutant Clon No. 14, Clon No. 17, Clon No. 23, Clon No. 28, Clon No. 386, Clon No. 457, Clon No. 581, Clon No. 729, Clon No. 772, Clon No. 865, Clon No. 944, Clon No. 996, Clon No. 1044, Red Spanish, Buitenzorg, and Variegata.

3. Two chromosomal types were found among the College pineapple clons. A heteroploid form of Clon No. 14 contains 60 chromosomes in the somatic tissue. A clon of Smooth Cayenne variety was definitely established by morphological and pollen characteristics to contain 75 chromosomes.

4. The meiotic behavior of the pineapple seems to be normal, for in diploid types the 25 bivalents in the heterotypic metaphase appears to be the regular feature of chromosome conjugation. In this manner, there was an equal distribution of 50 chromosomes, 25 going to one pole of the spindle and 25 to another pole. The gametogenesis in the pollen mother cells results in pollen tetrads with a haploid number of 25.

5. The existence of heteroploidy and triploidy appears to be explainable on the basis of abnormal formation of gametes on the egg side. Since chromosome doubling occurs in the egg gamete, triploidy results when a $2n$ ovule is fertilized with a normal haploid (n) pollen.

6. The bud mutations of pineapple studied, in the light of cytological findings, appear to involve no change in chromosome number, for they all contain the established somatic count of 50 chromosomes.

7. The genetic implications in connection with the existence of chromosomal types and future plans for pineapple breeding are discussed.

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ILLUSTRATIONS

PLATE 1. Somatic chromosomes in root tip cells of pineapple clons. × 3600.

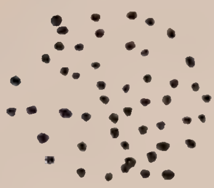
Fig. 1. Red Spanish, 50 chromosomes.
2. Buitenzorg, 50 chromosomes.
3. Variegata mutant, 50 chromosomes.
4. Mutant No. 14, 50 chromosomes.
5. Clon No. 17, 50 chromosomes.
6. Clon No. 23, 50 chromosomes.
7. Clon No. 28, 50 chromosomes.
8. Clon No. 772, 50 chromosomes.
9. Clon No. 14, 60 chromosomes.
10. Smooth Cayenne, 75 chromosomes.

PLATE 2. Stages in gametogenesis and meiosis of pineapple pollen mother cells.

Fig. 1. Resting nucleus from variety Variegata mutant. × 2212.
2, 3, 4, 5, and 6. Prophase stages from Clon No. 729. × 1106.
7, 8, and 9. Diakinesis from Clon No. 729 (Figs. 7 and 8, × 1106) (Fig. 9, × 2212).
10 and 11. Metaphase plates from Clons Nos. 729 and 581, respectively. × 2212.
12. Metaphase of heterotypic division from Clon No. 581. × 2212.
13. Late anaphase of heterotypic division from Clon No. 581. × 1106.
14. Telophase of heterotypic division from Clon No. 581. × 1106.
15. Late telophase with sign of restitution daughter nuclei from Clon No. 581. × 1106.
16. Metaphase of homotypic division, paraffin sections from Clon No. 581. × 2212.
17. Anaphase of homotypic division, smear preparation from Clon No. 14. × 2212.
18. A pollen tetrad from Clon No. 729. × 1106.

PLATE 3. Microphotographs of pollen mother cells undergoing mitosis.

Fig. 1. Meiotic figures of young pollen cells inside the loculus from Clon No. 581. × 1060.
2 and 3. Metaphases of heterotypic division from Clon No. 581. × 1800.
4. Metaphase of homotypic division from Clon No. 581 (See Plate 11, fig. 16). × 1800.
5. Normal pollen grains of a diploid variety from Clon No. 28. × 530.
6. Sterile and shrivelled pollen grains of the triploid Smooth Cayenne. × 530.



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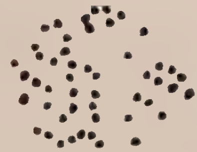

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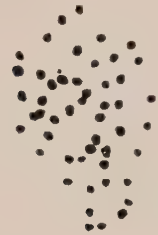

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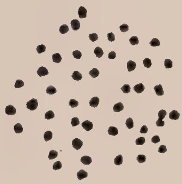

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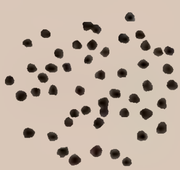

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Plate 1

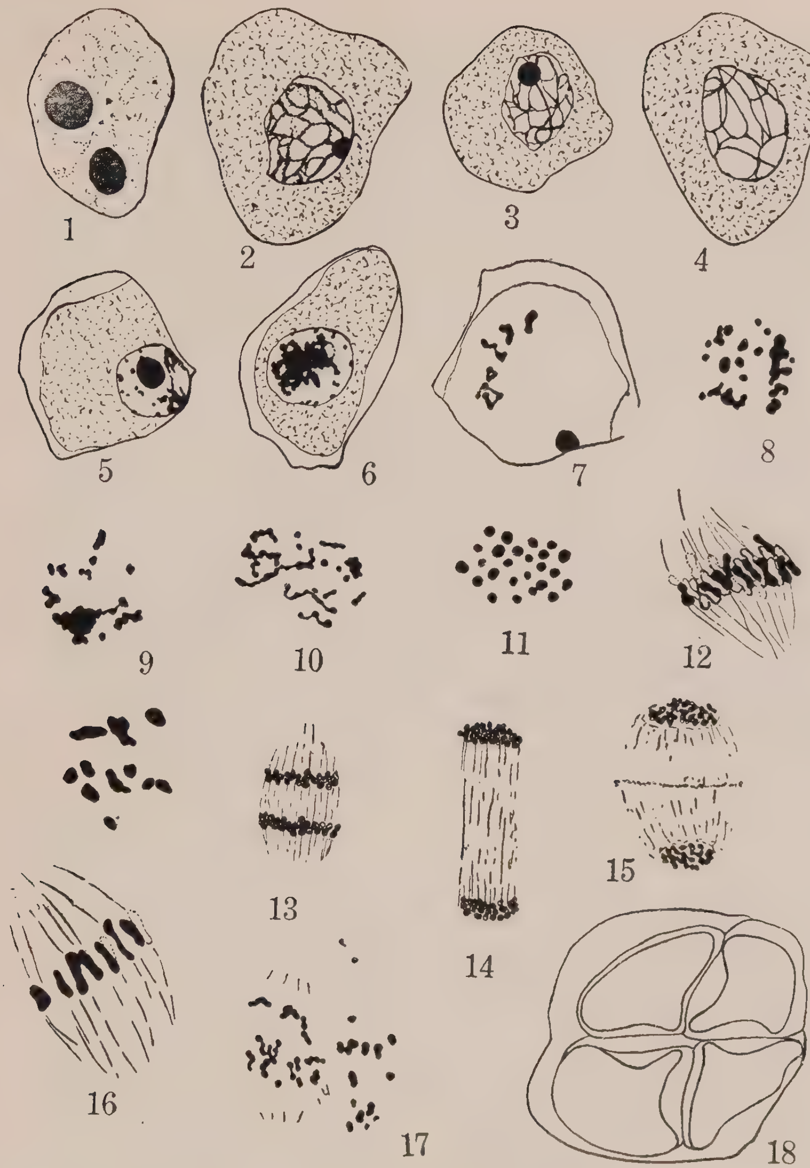

Plate 2

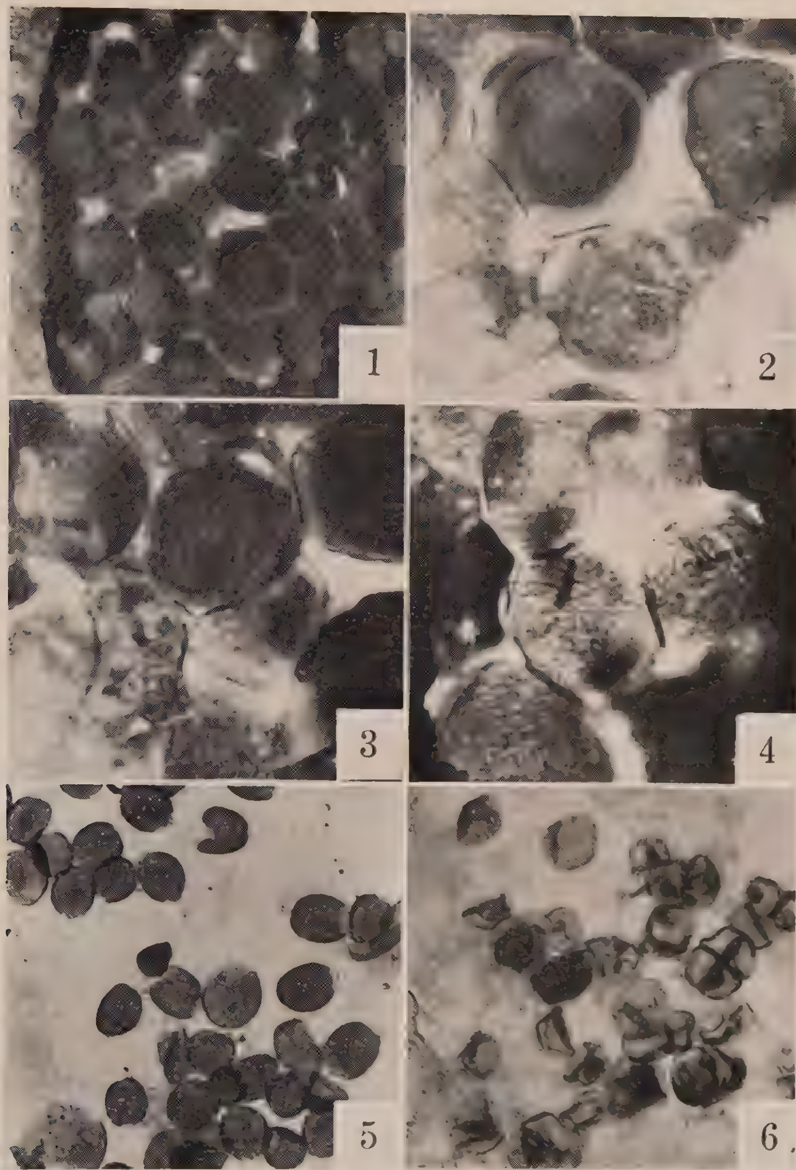

PLATE 3

TYPES OF TENANCY CONTRACTS ON RICE FARMS OF NUEVA ECIJA [1]

AMANDO M. DALISAY

One of the major problems of Philippine agriculture today is tenancy, especially share tenancy on the rice farms. Not infrequently there have appeared in the papers attacks on the evils of tenancy, and at the same time various solutions to the problem have been presented. It is interesting to note that critics differ on many points regarding tenancy, but one point in the whole question seems to draw the attention of all—tenancy contracts.

The importance of the contract to the whole problem of tenancy cannot be over-emphasized. In the words of W. J. Spillman, as quoted by Tichenor (1916), "The most important feature of tenant farming from the farm-management viewpoint is the character of the contract between landlord and tenant."

The bearing of tenancy contract on the all-absorbing tenancy problem is so important that the Philippine Legislature passed in 1933 the Philippine Share Tenancy Act (Act 4054), which was aimed to promote harmonious relations between the landlords and the tenants by regulating share tenancy. Good and wise as its objectives might be, the law defeated its purpose when it required the majority of municipal councils in a province to petition the Governor-General for its application. No petition has ever been presented.[2]

It is said that local legislation has failed to remedy the evils of tenancy, especially those that pertain to tenancy contracts, because of the lack of a thorough study and investigation of contractual relations as they actually exist on the farms. On the other hand, it is also charged that those who legislate usually belong to the land-owning class and are, therefore, interested to protect the landowners

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[1] Experiment Station contribution No. 1177.
Agricultural Economics 99 (Special Problems). Prepared in the Department of Agricultural Economics under the direction of Assistant Professor José E. Velmonte.

[2] Act 4054 was amended by Commonwealth Act No. 178 (approved November 13, 1936) to provide principally for an effective method of enforcement. As amended, the law "shall take effect after January 1, 1937, by proclamation to be issued by the President of the Philippines upon recommendation of the Secretary of Labor." This proclamation was made on January 20, 1937, to apply to the provinces of Bulacan, Nueva Ecija, Pampanga, Pangasinan, and Tarlac.

more than the tenants. Whatever the case, it is generally recognized that a close study of tenant-landlord relations should be made if there is to be an improvement of the lot of tenants or a reform of conditions as they now exist.

Inequality in the terms of tenancy contracts between the landowners and the tenants is generally recognized as one of the major causes of unrest on the rice farms. Daily the newspapers carry items of protests and petitions on the part of tenants and conflicts between landowners and tenants who, weighed down with the burden of unjust and exacting demands from their landowners, find a way of expressing their grievances through lawful channels or by violent and destructive means.

In view of the foregoing facts, it is imperative to determine present contractual relations between tenants and landowners. This needs be done so that possible remedies may be found to create peace and harmony on the farms and at the same time assure the tenants "a reasonable standard of living with stability."

There is very little information available on rice tenancy contracts in the Philippines.

Miller (1932) reported that "the kasama system is found on nearly all large holdings in the Central Plain, especially in the rice industry." He quoted Percy A. Hill, of Nueva Ecija, as saying that "in a typical kasama system the owner furnishes the tenant with the land, a carabao, and seed, the product of the crop to be equally divided between them after deducting the seed." He also found that the agreement between the tenant and landlord is sometimes, but not generally, a written one and is most often for one season.

Hill and Moe (1920), in their study of the relation between proprietor and tenant, found that tenants were at the mercy of the landlords with regard to debt and the rules governing it.

Aala (1935) found that the agreements between landlords and tenants were verbal and customary. He found, further, in his analysis of the contracts that from the tenants' standpoint, they were far from being oppressive and unjust.

Bongato (1933) studied farm ownership and tenancy in eight selected municipalities of Bohol, covering 201 tenant farms, and, like Aala, reported that only share tenancy existed, that the forms of contract were verbal, the duration indefinite, and the tenure relatively stable, as there was usually a close blood relationship between the landlords and the tenants.

Hester, Mabbun, and others (1924), in their study of some economic and social aspects of Philippine rice tenancies, found that the typical contract was verbal and customary, and arranged on a half-and-half share basis with the landlord supplying the land and the tenant both the labor and capital goods. They pointed out that the typical contract which applied to 70 per cent of the tenancies surveyed was equitable and just. This study, covering 830 tenancies, has been the most extensive and comprehensive work on Philippine lowland rice tenancies hitherto undertaken.

The variations in tenancy contracts all over the Islands are widely recognized. The Report of the Rice Commission, March 6, 1936, states among other things: "Tenancy contracts are not uniform throughout the Philippines. Their terms are influenced by various factors, such as abundance of labor supply, fertility of the soil and its adaptability to rice culture, transportation facilities, and risks from floods, droughts, typhoons, and plant pests and diseases."

Social unrest on the farms and in rural communities has been attributed to the lack of equity in contractual relations between landowners and tenants. Aala (1936) quotes Dr. Tayohiko Kagawa, a rural leader of Japan who visited the Philippines, as follows: "Unless the problem of landlord-tenant relation is solved, there is grave danger of peasant revolt." Miller (1929) pointed out that lately more serious agrarian movements than those heretofore have developed from the Philippine tenancy system and its abuses. Very recently a strong editorial of a popular weekly magazine [3] mentions, among other things, that the tenant mass is beginning to awaken to a realization of its exploitation and its bondage, and has already shown a disposition to effect its own reform. Referring to agrarian troubles in Nueva Ecija, Walter Robb, editor of *The American Chamber of Commerce Journal*, says rather humorously: "Social inquietude is rife at Cabanatuan,[4] where a large and strong provincial prison is a feature of the public works—and the province is governed under a strong constabulary." [5] While social unrest is a very serious outcome of unjust tenancy contracts, permanency of the tenancy system is another grave and lasting result. Velmonte (1934) pointed out that an unjust contract is one very important cause of the permanency of tenancy in the Philippines.

[3] The Philippines Free Press, Manila, November 21, 1936.
[4] The capital of the province of Nueva Ecija.
[5] Walter Robb. 1936. Cabanatuan: Rocky Ford.
The American Chamber of Commerce Journal, Manila, (May, 1936).

A careful and scientific study of landlord-tenant relations as they actually exist on the rice farms appears to be the opening wedge to a final solution of the tenancy problem. The Report of the Rice Commission recognizes this need for it says in part: "This tenancy system needs revision.... The Constitution of the Philippines gives authority to the Government to regulate the relationship between landowner and tenant. Such social legislation is of urgent importance, but it can only be enacted after a careful and thorough study of the problem involved, and formula adopted must be made adjustable to varying conditions in different sections of the country."

The objects of the present work were: (a) to determine the types of tenancy contracts on the different rice farms of Nueva Ecija; and (b) to find the relation between the types of tenancy contracts and the size of farms.

The survey was conducted in the principal rice-growing towns of Nueva Ecija in the Central Plain of Luzon. The field work covered a period beginning in the first week of April and ending about the last week of May, 1935. The work of compiling and tabulating the results covered the period from September, 1936, to December, 1936.

The principal rice-growing towns of the province of Nueva Ecija were visited during the survey. The towns of Cabiao, San Isidro, Santa Rosa, and Cabanatuan, in the southern part of the province, and the towns of Aliaga, Zaragoza, Quezon, Licab, and San Jose, toward the northern part were visited. In each town three to four rice farms, and sometimes more, were included in the survey.

During the survey, personal visits were made to farm owners or their farm managers (overseers) in each town covered by the study. The towns are far from one another, and the farms in each town are generally far apart, so that bus transportation (Rural Transit Co.) was used. In making the survey, questionnaires prepared by the writer were employed. With the aid of these questionnaires, farm owners or overseers in the different towns visited were interviewed. In some cases conversations with farm owners took place, and results of these interviews were noted down.

RESULTS AND DISCUSSION

Basis of classification and terms used

a. Basis of classification of types of tenancy contracts. The usual method of determining the type of tenancy contract is according to land, labor, and capital, the ownership of these factors by

either the landlord or tenant, and division of the crop. Hester, Mabbun, and others (1924), Bongato (1933), and Aala (1935) classified the types of tenancy prevailing in the regions covered by their studies according to this method. For the present work, a satisfactory and more detailed basis of classification appears to be as follows: *advances and interest, operating expense items, investment items, other items, and division of the crop.*

Advances and interest refer to the rations of palay with or without interest given to the tenant by the landowner, additional palay over and above the amount given as rations and which generally bears interest, and cash loans at interest advanced by the landowner for operating expense items, for the general needs of the tenant, and for other purposes.

Advances and interest are considered by the writer to be the most important features of the tenancy contract, because they are the means by which the tenants are oppressed and are the main causes of discontent and unrest on the rice farms. According to Miller (1929), it is through advances, interest, and debt that the planter often controls the actions of the tenant and holds him to the land, which the present writer's experience and observation have amply proved to be true. The devastating influence of advances and interest on tenancy was emphasized by Velmonte (1934), who in his analysis of some aspects of Philippine rural economy pointed out that "the system of advances of money or commodities made by landlords at usurious rates with a lien on the tenant's share of the crop has worked in practice to keep the tenant in bondage usually throughout his life, precluding any possibility of his saving and accumulating capital and acquiring land and rising to the status of an independent farmer."

Operating expense items include seed palay; expenses in transplanting, irrigation, harvesting, threshing, and hauling; and all other labor and expenses that the landowner or tenant may bear alone or share with one another. Seed palay is furnished by the landowner in all the farms surveyed and returned to him after threshing by being deducted from the total harvest.

Investment items include land, work animals, and tools and implements that the landowner or the tenant may furnish or own. It is obvious that the landowner furnishes the land which the tenant cultivates.

Other items include palay for food that the farmer can get from the field at harvesting time, and manual labor that the tenant fur-

nishes the landowner, aside from farm work. The writer finds these items very important in the tenancy contract. In some contracts these are incorporated; in most cases they are implied, and as understanding between the landowner and the tenant on these matters usually exists. Abuses on the part of tenants on farms where they are allowed to gather palay for food have led to severe restrictions on the part of landowners and even to complete prohibition. It was observed that strict enforcement of the prohibition to get palay for food from the farm and abuses on the part of landowners regarding manual labor that the tenant furnishes free appear to be among the causes of agrarian conflict in Nueva Ecija.

Division of the crop is uniform for all the rice farms covered by the survey, half-and-half on the net product. The net product is obtained by deducting from the total harvest the seed and the operating expenses which the landowner and tenant share equally, and which have been converted into palay, according to the terms of the contract. In some cases the *lugas sa mandala* (droppings during the building of the palay stack, or *mandala*) and the *bubo* (droppings during the threshing) are added to the gross harvest, but in most instances these are divided and are hauled after the farm operation in each case.

Sharing the crop, or *patuid* (Tagalog), or *liquidacion* (Spanish), is usually made on the *patio*. the place where threshing is performed. On large haciendas where the whole harvest, including the share of the tenant, is hauled to the landowner's *camarin*, the *patuid* is made in the overseer's office at the *camarin*, or in the landowner's house, if there is no overseer, or *katiwala*.

b. Terms used in this study. Shared equally, or *half-and-half* refers to the division of the operating expenses which are generally advanced in cash or kind by the landowner and converted into palay, according to the terms on advances and interest after threshing the harvest, and deducted from the total harvest (*kuha sa bunton*, or *bawas sa bunton*, Tagalog, meaning, "deducted or taken from the total harvest"); all such deductions from the total harvest go to the landowner who advanced the expenses. In very few cases the landowner and the tenant share the operating expenses by the landowner giving the tenant one-half of the expenses and the tenant providing the other half, as in the case of expenses in transplanting, or vice versa, in irrigation expenses.

Ration of palay refers to the amount of palay advanced by the landowner to the tenant for his food during the period of preparing

the soil, transplanting, and harvesting. This is with or without interest, depending upon the terms of the contract on advances and interest. In some large rice farms, rations of palay continue to be given to tenants even when work on the farm has practically stopped or is at a minimum. In the majority of cases, rations of palay are limited to a few cavans beyond which any amount taken is at a high interest agreed upon (*sa condicion*, Spanish-Tagalog).

Additional palay refers to the amount of palay taken by the tenant over and above the limit set for the ration of palay without interest. In most cases the ration of palay without interest is not sufficient for the needs of the tenant's family so that the tenant is obliged to borrow more palay at an interest agreed upon and in the majority of cases at very usurious terms not included in the written contract. Other landowners do not give palay beyond the limit set for the ration, and in such cases the tenants have to borrow it elsewhere.

Takalanan is the term commonly used to designate the interest rate of advances of palay in which the advanced palay is returned after harvest at the rate of 1½ cavans for every cavan borrowed or 3 cavans for every 2 cavans borrowed. Allied to this is the term *terciohan* which is used to designate such palay advances as are returned after harvest at the rate of 1⅓ cavans for every cavan borrowed or 4 cavans for every 3 cavans borrowed. Another terms is *takipan*, which conveys the highest interest rate for palay advances—2 cavans returned for every cavan borrowed or 4 cavans of palay for every sack (57 kilos) of rice advanced by the landowner. Since the terms *terciohan* and *takipan* as applied to palay advances to tenants were found in only one or two cases, these terms are not used in this study.

Current price refers to the market price of palay prevailing in the locality or town at the time palay or cash advances are made to the tenant or at the time these advances are paid in kind to the landowner.

Types of tenancy centracts

Among the 88 farms covered by this survey, three principal types ot tenancy contracts (table 1) have been found and classified mainly cn the basis of advances and interest. These three types are designated as type A, type B, and type C. Three subtypes (table 2) have also been noted, namely, subtype A, subtype B, and subtype C.

Type A. This type of tenancy contract covered 22 farms or 25 per cent of the total farms surveyed (See table 3).

(*1*) *Advances and interest.* Under type A the ration of palay without interest is limited, ranging from 2 to 10 cavans of palay.

Additional palay is advanced to the tenant to be paid in kind after harvest at the rate of 1½ cavans for every cavan of palay borrowed (*talindua*). Cash loans are made under *takalanan* to be paid in kind at the rate of 1 cavan palay for every ₱1.00 to ₱1.20 borrowed. There are also cases under this type (Type A) in which cash loans are returned in kind, the amount of palay to be delivered being determined on the basis of current price minus 20 to 25 centavos per cavan.

(*2*) *Operating expense items.* The seed in type A, as in all the other types, is advanced at no interest by the landowner. Transplanting expenses are borne by the landowner alone or shared equally. Irrigation expenses, on the other hand, are shared equally under this type of contract. The expenses in harvesting are borne by the tenant alone or shared equally. When the expenses for transplanting are said to be borne by the landowner alone, the landowner gives the tenant the amount of ₱4.00 to ₱5.50 per cavan seed. Should expenses exceed these amounts, the same are to be borne by the tenant. The labor or the expense in hauling palay after threshing is borne by the tenant alone. There are a few cases, however, when the landowner and the tenant share equally in the expenses, and a very rare case in which the landowner bears the expenses in hauling his share from the farm to the warehouse. All other labor and expenses are shouldered by the tenant alone.

(*3*) *Investment items.* It is obvious that, under the different types of tenancy contracts, land is furnished by the landowner. Work animals are generally furnished, under type A, by the tenant. In a few instances, the work animals are furnished with or without charge to the tenant by the landowner. If the work animals are furnished by the landowner free of charge, that is, without any charges at harvest for the services of the animals, the tenant is responsible for the care of the animals and is liable for their death or injury. Tools and implements are in all cases furnished by the tenant.

(*4*) *Other items.* In type A, the tenants are generally allowed to get palay for food from the field free during harvest. There are, however, cases in which tenants are not allowed to get palay from the field or, if they are allowed, the amount that may be taken is very limited, from ¼ to ½ cavan at one threshing [6] every week or two. Aside from farm labor, the tenants under type A may also be asked by their landlords to help gather firewood from the forest, do some repair work on the landowner's house, or mend fences enclosing the landowner's yard.

[6] Threshing of the palay gathered from the field is done with the feet.

(5) *Division of the crop.* From the total harvest determined after threshing, the seed which is advanced by the landowner and the charge for threshing (by rice thresher) are first deducted. Then the cash advances for operating expense items, such as transplanting, irrigation, and harvesting, in which the landowner and tenant share half-and-half, are converted into kind under the *takalanan* system (one cavan of palay for every ₱1.00 to ₱1.20 advanced) and deducted from the pile or total harvest. After these deductions, which go to the landowner, the net product is now divided equally between the landowner and the tenant. Palay advances and cash loans to the tenant give the landowner a lien on the whole share of the tenant from the net product. This is true of all other types. From the tenant's share of the net product are, therefore, subtracted the ration of palay without interest, the additional palay taken under *talindua*, with interest, and the cash loans under *takalanan* converted into kind. Whatever remains after these deductions goes to the tenant as his residual share of the year's crop.

Type B. There were 16 farms, or 18.18 per cent of the total farms surveyed under this type (table 3).

(1) *Advances and interest.* Unlike the terms of type A, there is no ration of palay advanced to the tenant without interest in type B. All rations of palay to tenant are with interest (*sa condicion*, or according to the terms of contract or agreement), that is, all rations of palay are advanced under *talindua.* In the majority of cases, no additional palay over and above the food needs of the tenant's family is allowed by the landowner, but there are emergency cases, when the tenant's need is very urgent, so that extra palay is advanced to the tenant under the same terms for the ration, that is, under *talindua.* Where milled rice, not palay, is given to the tenant as ration, the rice thus advanced is paid in kind (palay) on the basis of 3 cavans to 4 cavans palay (44 kilos) for every sack of rice (57 kilos). Cash loans are paid in kind after harvest on the basis of 1 cavan for every ₱1.00 borrowed (*takalanan*). Under type B, there are several cases in which payment in palay for the cash loans is determined by the current price of palay at the time of *patuid* (settlement of accounts), after 12 to 30 per cent interest has been added to the cash loans. For example, with palay quoted at ₱1.50 per cavan after harvest, a cash loan of ₱20.00 at 30 per cent interest, will have to be paid by the tenant after harvest with 17.33 cavans palay.

(2) *Operating expense items.* Like the terms in type A, the seed is advanced at no interest by the landowner. The expenses in

transplanting are either borne by the landowner alone or shared equally with the tenant; those for irrigation and threshing, shared equally; and those for harvesting, borne by the tenant alone or shared equally. In type B, as in type A, the tenant hauls the landowner's share after harvest. Where the landowner is said to bear the expenses in transplanting alone, the landowner gives the tenant a specific amount of from ₱5.00 to ₱6.00 per cavan of seed with which to pay transplanters. All other labor and expenses incurred on the farm are borne by the tenant alone—which is true of all the other types.

(*3*) *Investment items.* As in type A, the land is furnished by the landowner, and the work animals and implements are furnished by the tenant.

(*4*) *Other items.* In type B, as in type A, the tenant is free to get palay to be used for food from the field during the harvesting season. There are several cases, however, where the amount a tenant can thresh each time for food is limited by the landowner. The tenants under this type, not unlike those under type A, are expected to render personal service to the landowner and his family.

(*5*) *Division of the crop.* The procedure is the same as in type A. After deducting the seed and the expenses for transplanting, irrigation, harvesting and threshing which are shared equally, the net product is divided equally between landlord and tenant. The ration of palay taken under *talindua,* plus the interest under this system and the cash loans converted into kind under *takalanan* are deducted from the tenant's share.

Type C. This type covered 24 farms, or 27.27 per cent of the total farms surveyed (table 3).

(*1*) *Advances and interest.* Under type C the ration of palay without interest is limited from 5 to 20 cavans. Unlike those of type A and type B, there is no ration of palay with interest nor is there additional palay loaned to the tenant. Cash loans and advances under type C are in terms of *takalanan,* that is, returned in kind at the rate of one cavan palay per ₱1.00 to ₱1.20 loaned or advanced. It is not uncommon to find under this type a variation of which the basis of payment is the current price of palay per cavan at harvest minus a deduction of from 20 to 30 centavos. Under normal conditions, the latter will prove less burdensome than the former.

(*2*) *Operating expense items.* The method of sharing the expenses is no different from that under type A and type B. As usual the landowner advances the seed at no interest. The expenses for

transplanting are either borne by the landowner alone, in which case he gives the tenant a specific amount of from ₱5.00 to ₱8.00 per cavan seed, or by him and the tenant equally, in which case he advances the amount necessary. The expenses for irrigation and threshing are shared equally by the landowner and tenant. Hauling and all labor and expenses not mentioned above are borne by the tenant alone.

(3) *Investment items.* Not unlike the terms under types A and B, the landowner, under type C, furnishes the land, and the tenant furnishes the work animals and the tools and implements.

(4) *Other items.* The tenant is allowed, as in types A and B, to get palay for food from the field during the harvest season. It is not uncommon, however, to find under this type farms where the tenant is not granted this privilege, but instead, is required to get the palay needed for food from the landowner's camarin or warehouse. Not unlike types A and B, the tenant under type C is expected to help gather firewood from the forest for the landowner, repair the house, and work once in a while in the landowner's residential lot.

(5) *Division of the crop.* The same procedure is followed as in types A and B. The net product obtained after deducting the seed and the advances for operating expenses which are shared half-and-half is divided into two. From the share of the tenant are deducted the ration of palay taken without interest and also the cash loans under *takalanan* converted into kind.

Subtype A. One of the minor types of tenancy contracts found is subtype A which included 13 farms or 14.77 per cent of the total farms surveyed (table 3). This type is closely related to type A. The terms on operating expenses, investment, and other items are identical to those of type A. The only difference lies in the terms on advances and interest. The ration of palay without interest, like that of type A, is limited, but the amount which ranged from 6 to 15 cavans is larger than that in type A. Instead of the *talindua* for additional palay under type A, the extra palay over and above the limit for the ration in subtype A is converted into cash at the current price of palay at the time of lending, and returned in kind. The amount of palay to be paid is determined by the current price minus 20 to 30 centavos per cavan (table 2).

Subtype B. This subtype, another of the three minor types found in Nueva Ecija, included 6 farms, or 6.82 per cent of the total farms surveyed (table 2). All the terms on operating expenses are identical with those of subtype A, except that transplanting expenses

are borne by the landowner alone and harvesting expenses, solely by the tenant. The landowner gives the tenant ₱5.00 per cavan of seed for transplanting expenses. While the landowner is supposed to bear the transplanting expenses alone, in reality the amount given to the tenant is not enough, and the balance must be shouldered by the tenant. In some cases the landowner pays all the expenses. Subtype B closely resembles type B, but instead of the *talindua* and *takalanan* which apply on advances and interest in type B there is in this type somewhat milder forms of interest taking. There is no ration of palay without interest, but all rations are converted into cash at the current price of palay and returned in kind at the end of the crop year. The amount is determined by the current price per cavan of palay at the time of payment. It is not uncommon to find, however, that advances of palay are converted into cash at the current price during the time of lending and paid in kind after 10 to 14 per cent interest has been added. The amount of palay to be returned is determined by the current price of palay at the time of settlement.

Division of the crop in subtype B is much the same as in all the other types, except that seed, irrigation expenses, and threshing charges are deducted from the total harvest to get the net product which is equally divided between the landowner and the tenant. The various kinds of advances made by the landlord are deducted from the tenant's share of the net product.

Subtype C. This subtype prevails in the localities where the lands of one land-owning family of Cabanatuan are located. These lands are principally located in Quezon, Licab, and Guimba. Covering 5 large farms or haciendas, or 5.68 per cent of the total farms surveyed (table 3), subtype C closely resembles type C, one of the major types. The terms on operating expenses and investment are almost identical (tables 1 and 2), except that in subtype C, the landowner bears the expenses for transplanting, while the tenant bears the expenses for harvesting. Unlike type C, the landowner bears the expenses for irrigation. The tenants under this subtype are, however, required to construct, repair, and maintain the irrigation dikes and ditches. The difference between subtype C and the other types and subtypes lies in advances and interest and other items. Like type C, there is no ration of palay given to tenant with interest nor is there additional palay loaned to the tenant at very usurious rates. Unlike other types, the palay ration in subtype C is on the basis of 7 kilograms of palay per week for each member of the tenant's family throughout the crop year. This bears no interest. Instead of the

takalanan, the cash loans in subtype C are returned in kind after harvest. The amount returned is computed on the basis of the current price of palay minus cost of hauling to a milling center. Under *other items* in this subtype, the tenants are prohibited to get free from the field palay to be used for food during the harvest season; instead, the landlord obligates himself to advance palay without interest to the tenant for food needs during the period of harvest.

Division of the crop in subtype C is identical with all the other types of tenancy contracts.

Advantages and disadvantages of the different types of tenancy contracts

The types of tenancy contracts found on the rice farms in Nueva Ecija have their advantages as well as their disadvantages. The ration of palay bearing no interest (as found in types A and C) enables the tenant to have palay for food most necessary for the start of the working season, especially during the period of transplanting. Many tenants make use of this palay instead of what they have in store for their greater need during the interval between transplanting and harvesting when the landowner gives no rations. To many tenants *takalanan* and *talindua* (as found in types A and C) are in a way advantageous in that these forms of interest-taking give them a clear idea of what they actually owe the landowner and, to a certain extent, serve as a check on further indebtedness. In cases where the landowner bears alone the expenses of transplanting (as found in all types of contracts), that is, where the tenant is given by the landowner ₱4.00 to ₱5.50 per cavan of seed for transplanting expenses, the tenant's burden arising from the exactions of *takalanan* is thereby reduced. Even if the tenant alone bears the expenses of harvesting, when the landowner bears wholly the expenses of transplanting, the expenses are relatively small, because of the influence of coöperative labor and because of the privilege generally granted to the tenant to get palay free from the fields for his food. Because the tenants are allowed to get palay from the field free during the harvesting season (in all types of tenancy contracts, except subtype C), they are, therefore, enabled to avoid the further exactions of *talindua* for palay advances, and to raise a few chicknes, ducks, and swine. Thus we find that the ration of palay bearing no interest and the free palay from the field during harvest. together with the landowner bearing alone at times the expenses of transplanting, moderate somewhat the exacting nature of *talindua* and *takalanan* for palay and cash advances. Furthermore, we see that it is not so much

the division of the operating expenses between the landowner and the tenant, but it is the terms on the advances for the tenant's share of the expenses that make the type of contract less burdensome or severe.

The disadvantages of the different types of tenancy contracts are here pointed out as possible points wherein improvements may be made in landowner-tenant relations. In the first place, the ration of palay bearing no interest and limited from 2 to 10 cavans (as found in types A and C) is actually not enough for the food needs of the tenant and his family during the working season, especially when there are many children in the family. The situation is further aggravated in cases where all rations of palay bear interest or are taken under *talindua* or other forms of interest-taking (type B and subtype B). The practice of giving the tenant rations of palay bearing no interest for every week of the year (as found in subtype C) has tended to make the tenant too dependent upon the hacienda; consequently, it has worked to the landowner's complete control over the tenant's actions. Generally, tenants under this system lack the independence of action characteristic of tenants under the other types. The interests on palay and cash advances under *talindua*, *takalanan*, and other forms are actually excessive and almost unbearable. Interests on all advances do not take into account the period between the time of granting the loan and time of payment. Perhaps this has been adopted to simplify recording of accounts, but with the advance of knowledge in bookkeeping, certain changes should be introduced into the old method of keeping tenants' accounts. The custom of sharing operating expenses half-and-half embodied in the contract works disadvantageously, in actual practice, against the tenant because of the excessive interest on advances. It is preferable, therefore, that the landowner alone bear all the expenses of transplanting, and the tenant alone, all the expenses of harvesting. Another case in point is the practice of prohibiting tenants from getting palay for food from the field during harvest (as found in subtype C and in one or two cases under each of the other types). Where the tenants are required instead to get their ration from the landowner's *camarin* during the harvesting season, they become too dependent upon and too closely tied to the landowner's farm; it is not uncommon that the tenants find this a cause for grievance against the landowner, hence, a cause for agrarian conflict on the rice farms. Finally, the landowner's lien on the whole share of the tenant from the net product (as found in all types) works in actual practice to keep

the tenant continually indebted to the landowner because practically nothing is left to the tenant after the palay and cash advances plus their interests have been deducted. Strictly speaking, it becomes almost impossible under this practice for a tenant to attain the status of an independent land-owning citizen.

Form and nature of tenancy contracts

Forms of contracts. According to the University of California Experiment Station Circular 272 on California farm tenancy and leasing, the items common to every farm lease (or contract) are as follows:

1. Date lease is drawn
2. Names, designations, and addresses of contracting parties
3. Statement that property is being leased by landlord and lease accepted by tenant
4. Description of property being leased
5. Date when possession is to begin
6. Length of time that lease is to run
7. Types of farming to be followed
2. Rental rate, amount, and division of income; method of making payments—how, when, and where
9. Farming methods to be used
10. What is to be furnished by each party
11. How operating funds are to be provided; contribution of each party
12. Tenant's assurances and guarantees
13. Landlord's assurances and guarantees
14. Provisions for renewing or terminating lease
15. Safeguards to insure proper fulfillment of contract
16. Signatures
17. Witnesses
18. Sealing and recording

It is seen from the above that the first form of tenancy contract (Appendix A, form [1]), which is the more simple, does not include items 9, 14, and 15. The second form (Appendix A, form [2]), however, includes practically all the items as outlined above. In all forms of tenancy contracts, it was found that the duration of the contract was not specifically stated. It is usually implied to run for one cropping season, or sometimes longer, depending upon the continued congenial relations between the landowner and the tenant.

Forms of account book included in the booklet containing the contract. Generally, either form (1) or form (2) (See Appendix B) is included in the booklet containing the tenancy contract; the two together comprise the memorandum of advances kept in duplicate, one for the landowner and one for the tenant. In form

(1), which is the more simple, a loan or advance of palay under *talindua*, say 3 cavans, is entered in the column Palay for the amount of 5 cavans on the date the loan is made. When, for example, the loan is in cash but payable in kind under *takalanan*—one cavan for every peso borrowed—the amount, 10 cavans for a ₱10.00 loan, is entered in the same column. Cash advances with high interest or palay advances converted into cash and interest added are entered in the column Cash for the amount of the loan plus the interest agreed upon. The very usurious nature of these transactions is, therefore, hidden by the entries. Thus, advances as recorded appear to be innocent enough.

In form (2) the cash and palay advances are recorded separately, but the procedure in making the entry is the same as above.

Written vs. unwritten contracts. The tenancy contract was generally written for the rice farms surveyed. There were a few cases, however, of unwritten contracts on rice farms where tenants were closely related to the landowners by blood ties or customary association. Previous studies on tenancy, on the other hand, found the prevalance of unwritten or verbal agreements on tenant farms. Hester, Mabbun, and others (1924), Bongato (1933), and Aala (1935) have all found that the agreements between landowners and tenants were verbal and mostly governed by custom and tradition in the locality. Miller (1932) pointed out, however, that the agreement between tenant and landlord was sometimes but not generally a written one. Conditions in Nueva Ecija might be changing for the better because a student of tenancy can now count the number of tenant farmers who make no written contracts of one form or another with their landlords.

Students of tenancy are agreed on the necessity of written contracts between tenants and their landlords. According to Hibbard and Black (1920), the lease is not the important thing—it is the understanding; but the only way to get a complete understanding is to put all the terms of the lease down in writing. Bizzel (1921) in his study of farm tenantry in the United States pointed out that much of the conflict between landlord and tenant has grown out of mere verbal agreements. Bongato (1933) in his survey of Bohol tenancies scored the absence of written contracts by stating, among other things, that verbal covenants will not guarantee an adequate measure of justice, particularly to the tenant.

While tenancy contracts on the rice farms surveyed were generally written, these did not, in the majority of cases, include the

terms on advances and interest, although these items form the main basis of the contractual relations between tenant and landowner. The terms on advances and interest were often implied, and a complete understanding on *talindua* and *takalanan* or other forms of interest-taking generally prevailed between the contracting parties. As the tenant is a mere passive factor and the landowner the real active factor in the contractual relationship, the contract serves the interests of the landowner more than those of the tenant. It acts also as a check to shiftless tenants who wander from one hacienda to another and get into debt.

The length of tenure is an important feature of the tenancy contract. W. J. Spillman, quoted by Tichenor (1916), gave its importance as follows:

"Next to the division of income between labor and capital, the most important feature of the contract is the length of tenure it provides. . . . On this point depends very largely the effect of tenant farming on the fertility of the soil."

It is the consensus of opinion among all students of tenancy in the Philippines that the length of tenure is indefinite and largely dependent on the good-will between the landowner and the tenant. In the written contracts on the rice farms of Nueva Ecija, the duration of the contract was not formally stated. There was the understanding, however, that the contractual relation was for one crop year or longer, depending upon the good-will between the contracting parties. Such an indefinite length of tenure creates a situation of uncertainty and often is economically ruinous to the farm (Bongato, 1933). The bad influence of indeterminate length of tenure can be perceived by a careful observer as he travels through the rice farms of Nueva Ecija where tenant farmers manifest singular lack of incentive to improve or beautify their farm home surroundings and a very noticeable indifference towards civic and social activities of the locality.

A study of the written and unwritten tenancy contracts may point to the justice or unfairness of their terms. No type of tenancy contract in Nueva Ecija can, however, be pronounced ideal or equitable until a thorough study of costs and incomes under the different types has been made. It should be noted, on the other hand, that the provisions of the farm lease, according to Bizzel (1921), go to the heart of the farm tenantry problem, and every lease contract should, therefore, safeguard the fertility of the soil, attempt to secure for the landlord a fair interest on his investment, safeguard a good stand-

ard of living for the tenant and his family, and give the tenant an opportunity to acquire a surplus out of which he might provide a farm home of his own in due time. While studies of rice tenancy [Hester, Mabbun, and others (1924), Bongato (1933), and Aala (1935)] have shown that the typical contract was far from being unjust to the tenant but, instead, even more favorable to him in some respects,[7] the hand-to-mouth existence on a great number of rice farms, especially in Nueva Ecija, seems to present a very paradoxical situation in Philippine rural life.

Size of farms surveyed

Average size of farms visited. The average size of farms covered by the survey was 137.70 hectares (table 4). There were 88 farms surveyed with a total area of 12,118 hectares. The highest average size of farm (681 hectares) was under subtype C and the lowest (74.33 hectares) under type C. It is shown in table 4 that the smaller farms were under types of contracts with lighter or milder terms (types A and B and subtype A), while the larger farms came under types of contracts with heavier or more rigid terms (type B and subtypes B and C).

Size of tenant holding. The average size of tenant holding for all farms surveyed was 3.67 hectares (table 4). There was very little variation in it in the different farms visited and under the different types of tenancy contracts. It should be noted, however, that tenant holding varied from 3.26 hectares (subtype B) to 3.95 hectares (type A). Previous studies on tenancy have shown wide variations in the size of tenant holdings. Hester, Mabbun, and others (1924) found that it was 2.4 hectares in 830 tenancies surveyed. Miller (1932) pointed out that, for the Philippines as a whole and for all crops, about 79 per cent of the tenant farms are under 2 hectares in extent, but for the rice regions, the proportion is about 85 per cent. Bongato (1933) in his study of Bohol tenancies reported that they were surprisingly small, averaging for all towns 1.5 hectares. Aala (1935) in a survey of upland rice tenancies in Tanauan, Batangas, found that the average area for all farms under tenancy was 2.73 hectares.

Table 5 shows that actually the amount of seed planted by each tenant varied in each of the different types of tenancy contract and,

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[7] The conclusions of these workers as to the equity of tenancy contracts were based only on the terms covering the factors of production. Loans in money and in kind at very usurious rates which are shown here to impair the equity of the contracts were not covered by their investigation.

therefore, on each of the rice farms or haciendas. In type A the amount of seed palay to a tenant varied from 2.02 to 3.87 cavans and, on the basis of 20 gantas seed palay to a hectare, the size of tenant holding would be 2.52 to 4.83 hectares. In this connection it should be remembered that the size of rice field each tenant cultivates on the different rice farms of Nueva Ecija is determined by the amount of seed palay he sows each season, barring allowances for destruction by pests, diseases, or floods. Under subtype A the variation was about the same as in type A, but in type B the variation in the amount of seed to a tenant was larger, 1.87 to 4.54 cavans, corresponding to an area of 2.33 to 5.67 hectares. The variation under subtype B was about the same as under type B. Under type C the variation was of about the same extent as that under type A, 1.73 to 3.85 cavans seed, corresponding to an area of 2.12 to 4.81 hectares. The largest extent of the variation in the amount of seed palay to a tenant was found in subtype C, 2.10 to 5.90 cavans, corresponding to an area of 2.62 to 7.37 hectares. It is seen in table 5, therefore, that relatively smaller variations in the amount of seed to a tenant are found on farms under types of contract with lighter terms (types A and C), while relatively larger extent of the variation in amount of seed and, consequently, in the area of each tenant holding are found on farms under types of contract with rigid terms (type B and subtype C). This may be due to the selective nature of overseers on big rice farms in the admission of tenants who are first tried on smaller holdings and who are allowed to farm larger areas only after they are found to be honest and industrious. On the other hand, such rigidity of selection is not found on smaller farms, which are generally managed by their owners, because there is a close contact between the landowners and the tenants. Hence, the area given to each tenant on these smaller farms varies but little.

Number of tenants on the farms surveyed

There were wide variations in the number of tenants to each of the different rice farms covered by the survey (table 4). Under type A, there were 571 tenants on 22 farms surveyed, or an average of 25.95 tenants to a farm; under subtype A, 396 tenants on 13 farms, or an average of 30.46 tenants to a farm; under type B, 531 tenants on 16 farms, or 33.18 tenants to a farm; under subtype B, 354 tenants on 6 farms, or 59 tenants to a farm; under type C, 525 tenants on 24 farms, or 21.87 tenants to a farm; and under subtype C, 882 tenants on 5 farms, or 176.40 tenants to a farm. The average for all farms visited was 37.46 tenants to a farm.

Different types of contracts in a locality or town

Table 8 shows that several types of tenancy contracts may prevail in a locality or town. Three or four types were found to exist in any one locality. In the town of Cabiao, all the types, except subtype C, were found to exist. Where the table shows only one type in a town, there the survey was not done extensively. It would appear, therefore, that different types of tenancy contracts prevailed in a town of Nueva Ecija as there were individual differences among landowners in that locality.

Variations in the types of contracts between towns and localities

There were variations in types as there were different types of contracts in a town (table 8). These variations in types were more marked in the case of different towns or localities. No two towns were found to have exactly identical types or the same number of types. Taking the case of Cabiao and San Isidro, two neighboring towns, the writer found that while all the types, except subtype C prevailed in Cabiao, subtype B and subtype C were absent in San Isidro. Another example is the case of Quezon and Licab, two neighboring towns about 5 kilometers from one another. In Licab all the types, except subtype A, were found to prevail, while in Quezon types B, subtype B, and type C were absent. The variations become more marked when localities far from each other were considered. In Cabiao, subtype C was the only type which was found not to be present, while in Santo Domingo, about 59 kilometers away on the Provincial Road, type B, subtype B and subtype C, were absent, and all the others prevailed (see table 8).

Table 8 shows the distribution of farms according to the types of contracts among the different towns covered by the survey. Type A covered 22 farms located in 10 different towns, namely, Cabiao, San Isidro, San Antonio, Jaen, Zaragoza, Talavera, Santo Domingo, Quezon, Licab, and San José. Subtype A covered 13 farms distributed in 10 municipalities as follows: Cabiao, San Isidro, Santa Rosa, Cabanatuan, Aliaga, Zaragoza, Santo Domingo, Quezon, Muñoz, and San José. Under type B, on the other hand, were surveyed 16 farms located in 6 towns, namely, Cabiao, San Isidro, Gapan, Aliaga, Zaragoza, and Licab. Under subtype B were 6 farms located in 5 towns: Cabiao, Santa Rosa, Cabanatuan, Licab, and San José. Type C was found to cover 24 farms situated in 9 different municipalities, namely, Cabiao, San Isidro, Santa Rosa, Cabanatuan, Alia-

ga, Talavera, Santo Domingo, Licab, and San Jose. Subtype C included only 5 farms but these covered an area larger in the aggregate than the total area reported for any other type (table 3) and distributed in 3 towns: Quezon, Licab, and Guimba.

The most prevalent type of tenancy contract

Table 8 shows that the most prevalent type of tenancy contract was type A, covering 10 towns out of 16 towns under the survey. It would appear that subtype A was as prevalent in the different localities of Nueva Ecija, but the fact is that subtype A is a product of the effort among landowners to do away with the *talindua* in palay loans and advances in type A (table 1) and transform it into another system of interest-taking found in subtype A (table 2). Instead of the *talindua* system in which 1 cavan of palay borrowed is paid with 1½ cavans after harvest as found in type A, there is the system of interest-taking in subtype A in which palay borrowed is converted into cash at the current price of palay at the time the loan is made and then returned in kind (palay) after harvest; the amount is determined according to the current price at the time minus 20 to 30 centavos per cavan. It is seen, therefore, that there is merely a transformation in the form or system of interest-taking; the latter type usually works more disadvantageously to the interest of the tenants.

Relation of types of contracts to effective area of rice farms

There was an apparent relation between the types of tenancy contracts found and the size of farms covered by the survey (table 6). It may be noted that type A, subtype A, and type C prevailed on farms ranging in size from 10 to 200 hectares, type B on farms ranging also from 10 to 200 hectares with a noticeable trend, however, towards larger areas from 300 to as high as 1,000 hectares or over; and subtype B and subtype C on much larger farms comprising from 201 to 1,000 hectares or over. Table 6 shows that under type A majority of the farms, 19 or 86.36 per cent of the total farms under this type ranged in size from 10 to 200 hectares; under subtype A, 11 or 84.62 per cent of all the farms under this type consisted of the same area; and under type C, 19 or 79.17 per cent of all the farms under this type. Under type B the majority of the farms, 12 or 75.0 per cent of all the farms classified under this type, consisted also of similar areas ranging from 10 to 200 hectares; but it should be noted that 2 farms or 12.5 per cent of all farms under the type comprised from 301 to 400 hectares and that 1 farm or

6.25 per cent of the farms under the type consisted of 501 to as high as 1,000 hectares or over. Under subtype B, most of the farms, 4 or 66.67 per cent of all the farms under this type consisted of much larger areas, ranging from 201 to 400 hectares; and under subtype C, 4 or 80.0 per cent of all farms surveyed covered even much larger areas ranging from 501 to 1,000 hectares or over. It is apparent, therefore, that there was a tendency for types of contracts with lighter terms, as type A, subtype A, and type C, to prevail on smaller farms (10 to 200 hectares), while types with more strict terms, as type B, subtype B, and subtype C, tended to prevail on larger farms (200 to 1,000 hectares or over).

An explanation seems necessary for the relationship between the types of contracts and the size of farms. The adoption of types of contracts with comparatively milder terms (types A and C and subtypes A and B) in relatively smaller farms is mainly due to the closer contact between the landowners and tenants on these farms and to the opportunity for bargaining between them, the size of farms being insufficient to give the landowner power to dictate terms. On relatively larger farms, with consequently greater number of tenants, the contact between the landowners and tenants tends to diminish, and the wealth and social position of the large landowners give them the power to dictate terms to their tenants. Hence, the prevalence of types of contracts with relatively more rigid terms (type B and subtype C) on the larger farms. Moreover, the rigid terms of contracts on the large rice farms serve as a check to the entry of shiftless tenants.

Table 7 shows that as the rice farms increase in size there is the tendency for the landowners to delegate the management to overseers, or farm manager, or *katiwala*. With increase in size of farms comes the problem of absentee landlordism.

In the majority of cases tenants would prefer to have the landowners manage their farms because the latter are apt to understand more readily the tenant's problems and take immediate steps to remedy them. In table 7 is also shown that types A and C, and subtype A prevailed on farms managed by landowners; hence, the presence of milder or lighter terms of contracts where contact between landowners and tenants was close or where the landowners managed their farms.

Comparison with other studies

a. The typical contract on rice farms in Nueva Ecija. From our previous discussion and from the results of the survey, the fol-

lowing terms appear to be typical of a rice tenancy contract in Nueva Ecija:

1. Advances and interest

Ration of palay without interest: 2 to 20 cavans, returned after harvest.

Additional palay: *talindua;* or converted into cash and returned in kind on the basis of current price at the time of settlement minus 20 to 25 centavos per cavan.

Cash loans and advances: *takalanan*—payable in kind at the rate of 1 cavan for every ₱1.00 to ₱1.20 borrowed.

2. Operating expense items

Seed: Shared equally
Transplanting: by landowner
Irrigation: shared equally
Harvesting: by tenant
} or shared half-and-half in each case.
Threshing: shared equally
Hauling: by tenant
All other labor and expenses: by tenant

3. Investment items

Land: furnished by landowner
Work animals
Tools and implements
} furnished by tenant

4. Other items

Palay from the field: free to tenant
Extra labor for landowner: furnished free by tenant

5. Division of the crop

Half-and-half on the net product
Landowner with lien on the whole share of tenant
Outstanding or remaining debt: no interest

b. The typical contract in the kasama system of Central Luzon as found by Miller. Miller (1932), quoting Percy A. Hill, a progressive rice planter of Nueva Ecija, gives the following provisions of a typical contract in the kasama system of the Central Plain of Luzon, particularly Nueva Ecija:

1. Advances and interest

Ration of palay before and during transplanting: furnished by landlord without interest.

Ration of palay after transplanting: *terkiaan* (50 per cent increase) or *takipan* (100 per cent interest)

Cash loans: *takalanan*—paid in kind on the basis of one cavan for every 50 to 75 centavos loaned (a gain of 150 to 200 per cent)

Bugnos or advanced money: ₱15 to ₱75 to serve as a retainer.

2. Operating expense items

Seed: furnished by landowner } or shared half-and-half
Transplanting: by tenant }
Hauling: by tenant
All other labor and expenses: by tenant

3. Investment items

Work animals } furnished by landowner
Land }

4. Division of the crop

Half-and-half on the net product
Landowner with a lien on the whole share of tenant.

It is seen from the foregoing that the terms on advances and interest are heavier than those found in the present study; also the *bugnos*, or retainer, reported by Miller kept the tenants tied to the rice farm or hacienda. In all other respects, except in the case of work animals which Miller found to be furnished usually by the landowner, Miller's typical contract is similar to the typical contract found in the present work.

c. Hester and Mabbun's typical contract. Hester, Mabbun, and others (1924) found in their analyses of tenancies covered by eight studies in the provinces of Cagayan, Pangasinan, Bulacan, Laguna, Cavite, and Iloilo the following typical tenancy contract:

1. Advances and interest

(Not considered by the studies as parts of the contract)

2. Operating expense items

Seed: advanced or furnished by landowner
Labor for all farm operations: by tenant

3. Investment items

Land: furnished by landowner
Work animals } furnished by tenant
Tools and implements }

4. Division of the crop

Half-and-half on the net product.

The above typical contract was found to be equitable and just; the net income in relation to investment showed the same return of 12 per cent for each party. Mention was made of the terms on advances and interest and their influences, but not in relation to the contracts. Advances and interest were pointed out, however, as the main causes of tenant indebtedness; but these were not considered as parts of the tenancy contract.

d. The tenancy contract embodied in the Philippine Share Tenancy Law. The Philippine Share Tenancy Law (Act. No. 4054),

approved by the Philippine Legislature on February 27, 1933, to promote harmonious relations between the landlords and their tenants and to end once and for all the agrarian conflict in Central Luzon gives "what is believed to be an equitable contract" in the absence of any agreement to the contrary as follows:

1. Advances and interest

Grains or agricultural products loaned: not to exceed 10 per cent interest per agricultural year added to invoice price.
Cash loans for operating expenses: without any interest.
All other loans: not to exceed 12 per cent interest.
Loans limited to 50 per cent of average yearly tenant's share for 3 years.

2. Operating expense items

Planting, Harvesting, Threshing, Irrigation, Fertilizer: shared equally
Hauling: each party hauls his share.

3. Investment items

Land: furnished by landowner
Work animals, Tools and implements: furnished by tenant

4. Other items

Profits of auxiliary industry: to be shared equally.
15 per cent of tenant's share out of net product exempt from landowner's lien.
Outstanding debt or *sayad* converted into cash and to earn an interest not to exceed 12 per cent per annum; and once converted into cash not to be converted again into kind.

5. Division of the crop

Half-and-half on the net product.

These provisions of the tenancy law are far better than those of the typical contract found in Nueva Ecija today, and in many ways superior to the typical contract found by Hester, Mabbun, and others (1924). The contract embodied in the law makes a conscious effort to do away with *talindua, takalanan,* and other usurious practices of interest-taking, to bring down interest on loans, and prevent the landowner from getting control over the tenant's whole share through his lien.

SUMMARY AND CONCLUSIONS

1. An attempt is made to the determine the types of tenancy contracts prevailing in Nueva Ecija and the relation these types bear to the size of farms and the number of tenants.

2. The survey covered 88 farms with a total area of 12,118 hectares and worked by 3,297 tenants. The towns of Cabiao, San Isidro, Santa Rosa, Cabanatuan, Aliaga, Zaragoza, Talavera, Santo Domingo, Quezon, Licab, Guimba, and San Jose were visited during the survey.

3. On the different rice farms visited there were found three principal types of tenancy contracts, namely, type A, type B, and type C; and three subtypes, namely, subtype A, subtype B, and subtype C. These types were classified mainly on the basis of advances and interest. Other bases of classification used were operating expense items, investment items, other items, and division of the crop.

4. The different types of tenancy contracts are described.

5. Each type of contract has its own advantages and disadvantages. For all types, however, it was found that the ration of palay bearing no interest, ranging from 2 to 20 cavans, lightens the tenant's load resulting from *talindua* and the exactions of other forms of interest taking. The free palay from the field allowed the tenant during harvest, although very limited in some cases, also affords the tenant relief from the further exactions of *talindua* and other usurious rates of interest. On the other hand, it was found that the interest on palay and cash advances under *talindua, takalanan,* and other forms are actually excessive and almost unbearable. The custom of sharing operating expenses half-and-half embodied in the contract worked disadvantageously, in actual practice, against the tenant because of the excessive interest on advances; hence, it is preferable that the landowner alone bear all the expenses of transplanting and the tenant alone, the expenses of harvesting. The advances made to the tenants at usurious rates have also been found to keep the tenant indebted for life, precluding any possibility of his attaining the status of an independent land-owning citizen.

6. The forms of tenancy contract found on the different rice farms of Nueva Ecija were from the simple to the more complex legally-drawn contracts. The tenancy contract was generally written. In the written contracts on the rice farms of Nueva Ecija it was found that the length of tenure or the duration of the contract was not stated; there was only the understanding between the parties that the contractual relation is for one crop year or longer, depending upon mutual good relations existing between the landowner and the tenant. A study of the written and unwritten tenancy contracts may point to the justice or unfairness of their terms. Contracts in so far as the terms affecting the growing of the crop and

the division of the product are concerned may be considered reasonably fair as shown by Hester, Mabbun and others (1924). It is shown, however, in this paper that the implied terms on advances and interest, on which the tenant has a full understanding with his landlord, impair seriously the equity of the contractual relations. These advances with their excessively usurious rates of interest, in actual operation, rob the tenant of what in theory corresponds to him as his share of the crop. Final judgment, however, as to the equity of the different types cannot be made until after a thorough study of costs and incomes of both parties has been conducted.

7. The average size of all farms covered by the survey was 137.70 hectares. The highest average size of farm, 681 hectares, was under subtype C, and the lowest, 74.33 hectares, fell under type C. On the other hand, the average size of tenant holding for all farms surveyed was 3.67 hectares. There was very little variation in the average size of tenant holding on the different farms and under the different types of tenancy contracts. Actually the amount of seed planted by each tenant varied in each of the different types of tenancy contracts and, therefore, on each of the rice farms or haciendas. It was found that relatively smaller variations in the amount of seed to a tenant existed on farms under types of contract with lighter terms (types A and C), while a relatively larger extent of variation in amount of seed, and, consequently, in the area worked by each tenant, existed on farms under types of contracts with heavier terms (type B and subtype C).

8. There were wide variations in the number of tenants to each of the different farms surveyed. The average number of tenants to a farm varied from 21 tenants (type C) to 176 tenants (subtype C). The average for all farms visited was 37 tenants to a farm.

9. This study shows that different types of tenancy contracts may prevail in a locality or town. Three or four types were found to exist in any one locality.

10. These variations in types were more marked in the case of different towns or localities. No two towns were found to have exactly identical types or the same number of types.

11. The most prevalent type of tenancy contract in Nueva Ecija was type A, covering 10 towns out of 16 towns under the survey.

12. There was an apparent relation between the types of tenancy contracts found and the size of farms covered by the survey. There was a tendency for types of contracts with lighter terms, as type A,

subtype A, and type C to prevail on relatively smaller farms (10 to 200 hectares), while types of more rigid or heavier terms tended to prevail on comparatively larger farms (200 to 1,000 hectares or over.)

13. As the rice farms increase in size there is the tendency for the landowners to delegate the management to overseers or farm manager or *katiwala*, hence the diminishing contact between the landowners and their tenants. With the increase in size of farms comes, therefore, the problem of absentee landlordism. It has been found that types A and C, and subtype A prevailed on farms managed generally by landowners, hence, the presence of milder or lighter terms of contracts where contact between landowners and tenants is close or where landowners manage their farms.

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APPENDIX A

FORMS OF TENANCY CONTRACTS

(1) *A simple form of tenancy contract*

WITNESSETH:

That, we ____, tenant, of legal age, married, and residing at ____________________________________, Nueva Ecija, and _________________________________, landowner, of legal age, married, and residing at _________________________________, Nueva Ecija, have agreed upon the following terms:

1. That I, the tenant, have entered the tenancy relation with ____________ ________________________ (name of landowner) to farm his land which is as follows:

Crop	*Seed or area*	*Location of land*
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________

2. The work carabao and implements that I will use are my own property; and that said carabao has (male or female) this brand ________________ and is identified with Animal Registry No. ________________.

3. That it is my duty to give my service or that of my family to other tenants in the hacienda, as for example, in coöperative labor, taking up rice seedlings, harrowing, transplanting, harvesting, building palay stacks (mandala) of the harvested palay; and it is also my duty to live on the land that I will cultivate, and I will not, at any time during the period of work, leave the farm.

4. That the expenses in transplanting shall be borne by the landowner and shall not exceed the sum of FIVE PESOS (₱5.00) per cavan seed; and the expenses for harvesting shall be borne by the tenant alone; and the seed and charge for threshing, which shall be eight (8) per cent (of palay threshed), shall be equally divided (between the landowner and the tenant) and shall be deducted from the total harvest.

5. That the tenant shall not get any part of the harvest, while no settlement of his accounts (*pagtutuos* or *pagtutuid*) has been made, without the consent of the landowner or his overseer.

6. That the landowner's share and my (the tenant's) share shall be hauled to _________________________________ (name of town or place), or any place that is nearer, which the landowner may choose, at my own expense.

7. That my share of the crop and my work animal as described above shall serve as a guarantee for all my debts, in consideration of which I place them at the landowner's disposal.

8. That I, the party of the second part, _________________________________ (name of landowner), affirm the acceptance of all the terms of this contract.

9. Settlement of all accounts shall be made after the harvest has been hauled to the *camarin* and place specified above.

10. Aside from those terms, we have agreed upon the following:

In witness whereof, we have affixed our signatures hereunto in the province of Nueva Ecija, this ______________ day of ____________________, 19 ______.

________________________________	________________________________
Tenant	*Landowner*

Signed in the presence of:

____

____

(2) A more detailed and complete tenancy contract

Know All Men by these Presents:

That we ______________________________________ husband and wife, both of legal age and who shall be called in this contract "landlord," and the other party ____________________ of legal age and married to ____________________ (or single), farm worker, and who shall be called "tenant," do hereby approve in this contract to allow the latter to work a certain piece of land in the town of Cabiao, Nueva Ecija, P. I. under the following conditions agreed upon:

FIRST. That in accordance with the agreement hereto stated the tenant and his work carabao or carabaos must serve the landlord in the land assigned to him to work.

SECOND. The duties that the tenant and his animals must do are as follows:

(a) To cultivate the soil, to plow and harrow the field, and prepare the land thoroughly in order that it can be planted at the time to be determined by the landlord.

(b) To cut all cogon grass and weeds along the dikes (*pilapil*) and maintain the required height of these dikes in order to control the water in the paddy.

(c) To build other dikes (*tarundon*) for protection against flood, to make ditches (*sangka*) whenever in the opinion of the landlord or his overseer they are deemed necessary for the protection of the crop.

(d) To harvest or to let others harvest the palay at the right harvesting time in order to pile it into sheaves (*sipok*) and then into a stack (*mandala*) at a place designated by the landlord or his overseer, provided the place designated is within the boundary of the land belonging to the landlord.

(e) Not to work for or serve any other person except the landlord.

(f) After harvest, the palay harvested and other products, except sugar cane, that correspond as the share of the landlord shall be transported free by the tenant from the place of harvest to the landlord's storehouse provided that the said storehouse is within the limits of the hacienda.

(g) To build his own dwelling on the place designated by the landlord, to keep his surroundings clean, and to plant vegetables and other edible plants.

(h) To obey and execute all orders of the landlord or his overseer as long as these are for the benefit of a good harvest and good management of the hacienda; and it should be strictly understood in this contract that any time any order is disobeyed and for such cause the work, by force of circumstances, is done by others, there will be deducted from the tenant's share an amount of ₱1.00 for every day of his failure to do the said work, and this shall be without prejudice to the contents stated in the agreement No. 7 of this contract.

FOURTH. (a) In case the crop planted is palay, the seed and all expenses from the landlord, he will surrender the registry papers of his carabao or carabaos, and these will be retained and understood to be the security of his indebtedness.

FOURTH. (a) In case the crop planted is palay, the seeds and all expenses for planting, harvesting, and threshing shall be divided equally between tenant and landlord. The expenses for fuel (oil) in operating the irrigation plant shall be borne by the tenant; and all other expenses for the operation of the

machine, and water pump, and the wages of the operators shall be borne by the landlord. (b) If the crop planted is tobacco, corn, or any other, except sugar cane, the expenses, shall be divided equally between landlord and tenant; but it shall also be the duty of the tenant to transport the produce at his own expense from the place it is harvested to the storehouse within the limits of the hacienda. (c) In case the crop is sugar cane, the following agreement should be followed:

(1) The landlord shall give the tenant each year land suited for sugar cane, and it shall be the duty of the tenant to plow and harrow the land at his own expense and prepare it thoroughly for planting; to plant the said land with points, to use appropriate fertilizer, and to take good care of the crop until harvested; and in return for this work the tenant will receive for his share, ₱2.00 for every ton of sugar cane harvested.

(2) It shall be the duty of the tenant to work whenever the landlord deems it necessary, especially in the application of fertilizer to improve the fertility of the soil, and the production of a good ratoon crop in the succeeding season. For ratoon crop he shall receive ₱1.00 for every ton of sugar cane harvested from said land.

(3) The fertilizer and all expenses for cutting, hauling, and transporting of the canes shall be borne by the landlord. The tenant is required to give his service for the work above mentioned, but as payment or additional compensation, he shall be paid a daily wage or a contract payment per ton.

FIFTH. (a) The landlord shall give to the tenant 2 cavans of palay for every cavan of seed that he is planting, and this shall be paid to the landlord in the same amount by deducting it from the tenant's share in the coming harvest. (b) During the harvesting season and until the stacking of palay, the landlord shall give to the tenant one and a half (1½) cavans of palay from his storehouse for every one cavan of seed planted by him, and this shall be payable to the landlord in the same amount by deducting it from the total produce before equal division is made. (c) Aside from the agreement contained in (a) and (b) above, when the tenant is in further need, he may borrow additional money or palay or other necessaries from the landlord, provided he settles his debts to the landlord in the coming harvest on the basis of current price of palay per cavan by deducting them from his share under the following conditions:

(1) If the debt is in the form of money, it will bear an interest of not more than 12 per cent per annum.

(2) If palay is borrowed, this shall be valued at current price at the time it is borrowed, and to this amount will be added an interest of not more than 12 per cent per annum.

(3) All other indebtedness of the tenant will be converted into money at the time of borrowing, and to this amount will be added an interest of not more than 12 per cent per annum.

SIXTH. The landlord shall give to the tenant in payment of his work and services in planting and caring for palay and other crops, except sugar cane, one-half of the remaining produce that will be harvested from the land he is working after deducting all expenses already mentioned, but from this remaining half shall be deducted first any amount of the tenant's indebtedness.

SEVENTH. At any time the tenant is found deficient or fails to perform his duties under this agreement, the landlord can immediately expel him from the

hacienda. If upon his dismissal he is indebted to the landlord, the tenant's carabao or carabaos which are encumbered to the hacienda shall remain in the possession of the landlord until his debts are paid. Except for cause, the tenant can neither leave nor be asked to leave the hacienda unless sufficient time of six months is allowed to cause no inconvenience to either party concerned.

EIGHTH. In the event that the tenant becomes sick or dies before his work in the field is done, all work pertaining to his field may be done and managed by his companions who are tenants like himself.

NINTH. Whenever the tenant is asked to perform any other work not agreed upon in this contract, the landlord will pay him a daily wage current in the locality.

TENTH. This contract that we signed is written in both Spanish and Tagalog, but in case of disagreement in its interpretation, the Spanish copy shall prevail.

And in testimony of all these terms stated above, we signed this contract this ____________________ day of ______________________ 19_____ in the town of Cabiao, province of Nueva Ecija, P. I.

In the presence of: For:

__________________________________ __________________________________
Landlord

__________________________________ __________________________________
Tenant

APPENDIX B

Forms of Account Book Included in the Booklet Containing the Contract

(1) Cash and palay advances together on one page

Pangkaraniwang Pinaggugulan na Pinagpalualan
(Ordinary expenses advanced to tenant)

Petsa (Date)					*Pagkakautang* (Debt)	
BUWAN (MONTH)	ARAW (DAY)	KINAUUKULAN (PURPOSE)	SALAPI (CASH)		PALAY	
					Kaban (Cavans)	Salop (Gantas)
			pesos	*centavos*		
		Total				

(2) Palay and cash advances on separate pages

PALAY [a]

19.....		MGA BAGAY NA KINUHA (ARTICLES TAKEN)	CAVAN	KILOS	KABUUAN (TOTAL)	
BUWAN (MONTH)	ARAW (DAY)					
					cavan	*kilos*
		Total				

[a] Debts under this account are taken in the form of palay or cash converted into palay.

KUALTA [b]
(CASH)

					(BLANK)	KABUUAN (TOTAL)
			pesos	*centavos*		
		Total				

[b] Debts under this account are taken in cash or palay converted into cash.

TABLE 1

Three principal types of tenancy contracts classified mainly on the basis of advances and interest

ITEMS IN THE CONTRACT	TYPE A (22 FARMS)	TYPE B (16 FARMS)	TYPE C (24 FARMS)
	terms of contract	*terms of contract*	*terms of contract*
I. Advances and interest			
Ration of palay without interest	Limited to 2 to 10 cavans	(None)	Limited to 5–20 cavans
Ration of palay with interest	(None)	*Talindua*—returned in kind at 1½ cavans for every cavan borrowed	(None)
Additional palay	*Talindua*—returned in kind at 1½ cavans for every cavan palay borrowed	(None)	(None)
Cash loans	*Takalanan*—paid in kind at one cavan per ₱1 to ₱1.20	*Takalanan*—returned in kind at one cavan per ₱1 advanced	*Takalanan*—in kind at 1 cavan per ₱1 to ₱1.20
II. Operating expense items			
Seed	Shared equally		
Transplanting	Borne by landowner alone or shared 50–50		
Irrigation	Shared equally[1]		
Harvesting	Borne by tenant alone or shared 50–50	Identical	Identical
Threshing	Shared equally		
Hauling	Borne by tenant alone		
All other labor and expenses	Tenant alone		
III. Investment items			
Land	Furnished by landowner		
Work animals	Furnished by tenant	Identical	Identical
Tools and implements	Furnished by tenant		
IV. Other items			
Palay for food from field during harvest	Tenants are free to get	Identical	Identical

[1] On farms where there is government irrigation system.

TABLE 2

Subtypes of tenancy contracts classified mainly on the basis of advances and interest

ITEMS IN THE CONTRACT	SUBTYPE A (13 FARMS)	SUBTYPE B (6 FARMS)	SUBTYPE C (5 FARMS)
	terms of contract	*terms of contract*	*terms of contract*
I. Advances and interest			
Ration of palay without interest	Limited to 6 to 15 cavans	(None)	7 kgm. of palay per week per member of tenant's family returned after harvest
Ration of palay with interest	(None)	Converted into cash at C. P. and returned in kind at C. P.; or converted into cash and 10–14% interest added and returned in kind at C. P.	(None)
Additional palay	Converted into cash at C. P. at time of loan and returned in kind at C. P. minus 20 to 30¢	(None)	(None)
Cash loans	*Takalanan*—in kind at one cavan per ₱1 to ₱1.20	At 12 to 14% interest and returned in kind at C. P. (current price) of palay	Returned in kind at C. P. (current price of palay) minus cost of hauling to milling center.
II. Operating expense items			
Seed	Shared equally	Shared equally	Shared equally
Transplanting	Borne by landowner alone or shared 50–50	Borne by landowner alone	Borne by landowner alone
Irrigation	Shared equally [1]	Shared equally [1]	Borne by landowner alone [2]
Harvesting	Borne by tenant alone or shared 50–50		
Threshing	Shared equally	Identical	Identical
Hauling	Borne by tenant alone		
All other labor and expenses	Tenant alone		
III. Investment items			
Land	Furnished by landowner		
Work animals	Furnished by tenant	Identical	Identical
Tools and implements	Furnished by tenant		
IV. Other items			
Palay for food from field during harvest	Tenants are free to get	Tenants are free to get	Tenants are not allowed

[1] On farms where there is government irrigation system.

[2] Landowners have private irrigation systems.

TABLE 3

Area of farms and number of tenants classified according to types of contracts

TYPES	NUMBER OF FARMS		SIZE OF FARMS		NUMBER OF TENANTS	
	Total number under each type	Per cent of total	Total area under each type	Per cent of total	Total number under each type	Per cent of total
Total for all types	88	100.00	12,118	100.00	3,297	100.00
1. Type A	22	25.00	2,259	18.64	571	17.32
2. Subtype A	13	14.77	1,452	11.98	396	12.01
3. Type B	16	18.18	1,952	16.11	531	16.11
4. Subtype B	6	6.82	1,157	9.55	354	10.74
5. Type C	24	27.27	1,784	14.72	525	15.92
6. Subtype C	5	5.68	3,405	28.10	882	26.75
Unclassified	2	2.27	109	0.90	38	1.15

TABLE 4

Number and size of farms, and number of tenants under the different types of tenancy contracts

TYPE OF CONTRACT	NUMBER OF FARMS IN EACH TYPE	NUMBER OF TENANTS		SIZE OF FARMS		AVE. SIZE OF TENANT HOLDING UNDER EACH TYPE
		Total area of farms under each type	Average size per farm under each type	Total number of tenants under each type	Average number of tenants per farm under each type	
		hectares	*hectares*			*hectares*
1. Type A	22	2,259	102.68	571	25.95	3.95
2. Subtype A	13	1,452	111.69	396	30.46	3.66
3. Type B	16	1,952	122.00	531	33.18	3.67
4. Subtype B	6	1,157	192.83	354	59.00	3.26
5. Type C	24	1,784	74.33	525	21.87	3.39
6. Subtype C	5	3,405	681.00	882	176.40	3.86
Unclassified	2	109	54.50	38	19.00	2.86
Total	88	12,118	137.70	3,297	37.46	3.67

TABLE 5

Comparison between the average size of tenant holding and the actual area cultivated by each tenant [a]

TYPE OF CONTRACT	COMPUTED AREA PER TENANT	ACTUAL AREA FARMED BY EACH TENANT					
	Average size of tenant holding under each type of tenancy contract	Average amount of cavans seed palay under each tenant in each type of tenancy contract			Average size of rice field in hectares cultivated by tenant according to seed palay in each type		
	ha.	*minimum*		*maximum*	*minimum*		*maximum*
1. Type A	3.95	2.02	—	3.87	2.52	—	4.83
2. Subtype A ...	3.66	1.86	—	3.45	2.32	—	4.31
3. Type B	3.67	1.87	—	4.54	2.33	—	5.67
4. Subtype B ...	3.26	1.60	—	4.50	2.00	—	5.62
5. Type C	3.39	1.70	—	3.85	2.12	—	4.81
6. Subtype C ...	3.86	2.10	—	5.90	2.62	—	7.37

[a] The area cultivated by a tenant was determined on the basis of seed planted; that is, 20 gantas equal 1 hectare.

TABLE 6

Relation of the types of tenancy contracts to the size of farms

RANGE IN SIZE OF FARMS	TYPE A		SUBTYPE A		TYPE B		SUBTYPE B		TYPE C		SUBTYPE C	
	Number of farms	Per cent of total	Number of farms	Per cent of total	Number of farms	Per cent of total	Number of farms	Per cent of total	Number of farms	Per cent of total	Number of farms	Per cent of total
hectares												
Less than 10 hectares	—	—	—	—	1	6.25	—	—	3	12.50	—	—
10– 100	16	72.72	9	69.23	9	56.25	2	33.33	15	62.50	—	—
101– 200	3	13.64	2	15.39	3	18.75	—	—	4	16.67	—	—
201– 300	1	4.55	1	7.64	—	—	3	50.00	2	8.33	1	20.00
301– 400	2	9.09	—	—	2	12.50	1	16.67	—	—	—	—
401– 500	—	—	1	7.69	—	—	—	—	—	—	—	—
501–1,000 or over	—	—	—	—	1	6.25	—	—	—	—	4	80.00
	22	100.00	13	100.00	16	100.00	6	100.00	24	100.00	5	100.00

TABLE 7

Types of tenancy contracts and the management of the different farms

TENANCY CONTRACT	NUMBER OF FARMS IN EACH TYPE	MANAGED BY LANDOWNER		MANAGED BY OVERSEER	
		Number of farms	Range in size of farms	Number of farms	Range in size of farms
			ha.		*ha.*
Type A	22	15	14–200	7	40– 400
Subtype A .	13	9	24–250	4	50– 500
Type B	16	10	7–120	6	50– 514
Subtype B .	6	3	25–330	3	48– 274
Type C	24	20	7–250	4	65– 216
Subtype C .	5	—	—	5	205–1,200
Total	86	57	—	29	—

TABLE 8

Prevalence of types of tenancy contracts

TYPE OF CONTRACT / TOWNS	TYPE A	SUBTYPE A	TYPE B	SUBTYPE B	TYPE C	SUBTYPE C	TOTAL NO. OF FARMS
Total number of farms under each type	No. of farms 22	No. of farms 13	No. of farms 16	No. of farms 6	No. of farms 24	No. of farms 5	86
1. Cabiao	4	1	6	1	1	—	13
2. San Isidro	3	1	1	—	4	—	9
3. San Antonio	1	—	—	—	—	—	1
4. Jaen	1	—	—	—	—	—	1
5. Gapan	—	—	1	—	—	—	1
6. Sta. Rosa	—	1	—	1	1	—	3
7. Cabanatuan	—	1	—	2	1	—	4
8. Aliaga	—	2	3	—	5	—	10
9. Zaragoza	2	1	4	—	—	—	7
10. Talavera	3	—	—	3	3	—	9
11. Sto. Domingo	2	1	—	—	5	—	8
12. Quezon	3	2	—	—	—	1	6
13. Licab	2	—	1	1	3	2	9
14. Muñoz	—	1	—	—	—	—	1
15. Guimba	—	—	—	—	—	2	2
16. San José	1	2	—	1	1	—	5
Number of towns under each type	10	10	6	5	9	3	

MOUNT MAQUILING AND ITS PRESENT VOLCANIC EMISSIONS [1]

ENRIQUE ABELLA Y CASARIEGO

EDITOR'S NOTE

The present translation into English of this important work is published herein for the first time. The original article in Spanish, which appeared over fifty years ago, has long been out of print and is not generally accessible. In the remarkably accurate and painstaking accounts of the physiography and geology of the Maquiling area, this paper has remained unsurpassed to this day. Although some of the ideas presented may have become outmoded by recent findings, the work should be within the reach of a wider circle of readers interested in this particular region, not only for its historical value, but also as a basic guide to a fuller knowledge of this locality.

Enrique Abella y Casariego was chief of the Philippine Mining Bureau from 1889 to 1897. In the words of Prof. Warren D. Smith, he was "by far the ablest of the earlier investigators [on Philippine geology]." Born in Manila in 1848. Educated in Spain, where he obtained the degree of mining engineer in 1869. Worked in the mines of Hornachos and later in the mining office at Asturias, Spain, until 1878, when he returned to the Philippines, to become inspector of mines. Left the Philippines, never to return, in 1897, as a result of the revolution. Died in 1913.

On account of the repair work being done on the premises of the General Inspection Division (Mining Engineer Corps) during the month of May in 1881, it was not possible to carry on any serious investigation work in the office. For this reason and with the object of continuing the study already begun in Central Luzon by the "Inspector General," then absent in the Peninsula [Spain], we made an excursion to the shores of Laguna de Bay and began the study and exploration of Mt. Maquiling which is the first great mountain mass one sees when traveling beyond Manila. We made this choice also on account of the fact that we did not wish to be far from the capital so that we could attend promptly to any emergency work which might arise, since at that time there was no other engineer of the division in the entire Archipelago.

We were able to devote but little time to our field exploration and study because the rains and storms prevailing at that season

[1] Translated by José B. Blando, School of Forestry, from the original in Spanish, entitled "El monte Maquilin (Filipinas) y sus actuales emanaciones volcanicas." 28p. *2 pl.* Madrid: Tello. 1885. *Also* Boletin de la Comisión de Mapa Geológica de España **12**. 28p. *2 pl.* Madrid. 1885.

forced us to leave the slopes of Maquiling and return to Manila. However, we nearly completed the reconnaisance.

In this excursion we were accompanied by assistant Don Secundino Fernandez Miranda who executed the work which we entrusted to him with zeal and exactness. It is apropos also to mention that, thanks to his energy and interest, he was able to reach with a native the highest peak of the mountain, the barometric height of which he took, while we, the rest, dizzy and tired with hard climbing, remained twenty meters below, overlooking the interior wall of the crater. We ought to mention also the draftsman Martinez, who, not only made good sketches of the mountain and its solfataras, but also helped efficiently in the making of the topographic surveys, thanks to the experience which he had acquired in this kind of work in the survey of Cebu.

We have omitted in the present writing some of the illustrations which we thought at first to have included, because they were found to be not indispensable, and because their completion would retard the presentation of this work which has already been delayed by other more important duties, but which we had always considered a sort of moral obligation that we are fulfilling at present. The topographic and geologic sketch of Maquiling and its vicinity and the view of the mountain seemed to us sufficient to explain and illustrate the data which we have been able to gather and which we have the honor to state in writing as follows:

LOCATION AND EXTERIOR ASPECTS OF MT. MAQUILING

On entering Manila Bay on a clear day, one can see to the southeast, rising isolatedly behind a border of low coasts and limiting the horizon, a conical mountain named Maquiling. We cannot, however, consider this mountain as a part of the shore of the great bay, the reason why the mountain can be seen distinctly from the bay being the great elevation of the mountain and the fact that nothing intervenes between it and the bay, except the great plains of Manila and the province of Cavite, which extend to the shores of the bay. In reality, this mountain is situated in the interior of the island of Luzon, rising between two large lakes, improperly called Bay and Bombon, and forming the boundary between the central provinces of Batangas and Laguna.

Its exterior form varies according to the direction from which it is observed. From Laguna de Bay, that is to say, from the north, although one sees it rise between the towns of Bay and Calamba in

a conical form truncated by four small peaks, no one would ever suspect its volcanic origin, but when viewed from Bombon Lake or from the SW, the upper part of a crater with craggy edges appears and relieves all doubts as to the character and origin of the mountain and easily explains its other peculiarities as well.

Its isolation, however, is not so absolute that its slopes arise on every side from the level of a lake or of a great plain as do the slopes of other volcanic cones of Luzon.[2] Although considerably depressed towards the west, it joins the Suñgay mountain in that direction by a mountain pass about 120 meters above sea level; to the east a series of hills connects it with the small mountain chain of Imuc and Calauan; to the south, with the plateau of Tanauan and Alaminos, with an elevation of 130 meters, and some secondary hills join it to Malarayat, and, lastly, to the north, its lower slopes, which are the lowest around the mountain, submerge under the waters of the large Laguna de Bay.

HYDROGRAPHY

RIVERS AND CREEKS

As a result of the above-mentioned circumstances, the hydrography of Maquiling does not absolutely have that radial form which the hydrography of similar cones usually present. Two of the streams which rise in the interior of the crater, coming out from the southwest and southeast, respectively, describe two great curves to the north, bounding the western and eastern flanks of the mountain, and flow over the lowest part of its slopes. These two streams are the most conspicuous of those which form the hydrographic system of the mountain under discussion.

The western stream begins at the southern foot of the cliff which faces the interior of the crater and belongs to the highest peaks on the western rim of the crater, but this stream is not permanent above the three springs which feed it, the only ones existing in that part of the mountain. The first spring, named Guja, situated at an elevation of 483 meters, is very small and in the dry season it disappears in the fissures of rocks a few steps beyond its source. Lower down, two other springs appear: first, the Saimsin at an elevation of 327 meters and then, almost at the same elevation, the Comba, both of which have an abundant supply of running water which transforms the dell called Bisoag into a permanent stream. This

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[2] Taal, Corregidor, Pulo Caballo, and Arayat are examples of this type.

then descends S and SW through one of the openings of the crater of the mountain, then unites with the river Tanauan, of which it is one of the principal tributaries.

The Tanauan River and its tributaries

With the name of Tanauan, the stream which we speak of takes a north northwest direction between the adjacent towns of Tanauan and Santo Tomás, bends afterwards towards the northeast and empties, with the name of San Juan, into Laguna de Bay, near Calamba, where its sediments form a pronounced point. The river, in its course through the plateau of Tanauan and Santo Tomás, has a rocky bed embanked between walls 20 to 35 meters high at certain points, but its lower course is shallow and clayey, and its waters spread over the plain between the town and the rich valley of Calamba. This river has abundant tributaries generally coming from the sides of Maquiling, the most important of which is called Biga, forming the boundary between Batangas and Laguna.

The Pinquian Creek and its tributaries

The other stream which bounds Maquiling on the east rises from the southeast of the mountain. With the name of Pinquian, it flows towards Barrio Biten, bends north of the hill called Olila towards the northeast, cuts a deep rocky bed through the small chain of hills in the Imuc district, reaches the plain which extends from Calauan to Bay, fertilizing it, and then flows north of this town into Laguna de Bay. Its middle course is called Tigas River, while its lower course, the Mabacan, except that part between the town of Bay and the lake, which is usually called by the name of the town. In its upper and middle parts the Tigas or Mabacan River receives some tributaries of minor importance but, upon reaching the plain, it is joined on the left bank by the important Cayac river which collects all the waters from the northern slopes of the Imuc range west of the Mabacan River, through its two tributaries, called Malanday and Lalaog, respectively.

The Cambantoc River

Aside from the aforementioned rivers, the most important river, because of its course and the large volume of water which it carries, is the Cambantoc. It rises from a deep opening on the eastern side of the crater and descends in this direction down the base of the secondary hills called Mabilog and Bulalo and then bends towards the northeast and north successively to empty into the lake, west of

the town of Bay. It is deeply intrenched in its middle and lower courses, although not so deeply as the two rivers described above.

Molawin River

It rises very near the head of the Cambantoc and follows a course almost parallel to the latter although it straightens towards the north and also empties into the lake east of Mayondon hill and point.

Dampalit River

Another river which is well known for its copious waters and beautiful cascade near the town of Los Baños is the Dampalit. It rises north of the peak, flows NNE, with copious waters forming in its lower part a deep gorge, and empties near the town of Los Baños.

Maitim River

On account of its relative importance, it is also worthwhile to mention the Maitim, or Boot River which meanders between Cambantoc and Molawin, bounding on the east the hillocks of Tuntuñgin, and likewise empties into the lake.

Other streams

Lastly there are also, beside those already described, a multitude of secondary streams, some of which are intermittent and others permanent, such as the Pansol, Salunu, and Lecheria streams.

LAKES AND POOLS

Subsidiary features of the hydrography of Mount Maquiling are found in the various lakes and pools, all of which are of volcanic origin and many of which show actual manifestations of volcanic activity.

Alligator Lake

The Alligator Lake, the largest of these lakes and pools, is simply a crater of elliptical form more than one kilometer long and filled with water to approximately the same level as that of Laguna de Bay.

The small hill which contains this crater is shown in all the sketches that we have seen as a small island named Sumili. It is, therefore, probable that the sediments deposited at the strait which probably existed between this small island and the coast of Los Baños in front of the mouth of the copious Dampalit has caused the visible rise [3] of the level of the lake and has produced the existing connection which, in fact, is very low and in many places muddy.

[3] The ancient town of Bay which is the oldest of those founded along the shores of the lake, is now covered by its water west of the mouth of the river.

The pools of Tadlac

This phenomenon is observable along the coast between the crateriform hill and the mouth of the Dampalit, where many pools are formed, nearly all of which are hydrothermal and are connected with each other by a wide estuary, called Tadlac.

Other pools and the Natugnos Lake

Some pools of the same type exist near the road from Calamba to Los Baños but we shall deal with them and the muddy lake of Natugnos when we discuss the volcanic phenomena which actually occur in Maquiling, since all of them are caused by the same igneous subterranean action.

Springs

Likewise we are deferring to that same section the description of the numerous thermo-mineral springs which issue from the slopes of this mountain.

OROGRAPHY

Maquiling does not have that simplicity of form which other perfectly conical volcanoes have, such as the Mayon, for example. The crater of Maquiling is eroded on all sides and its slopes are broken by secondary hills. Besides, Maquiling is covered with thick tropical vegetation which hinders geognostic study.

THE FORM OF THE CRATER AND ITS EDGES

The crater has two deep cuts on the SW and ESE which give way, as we have already said, to the waters which collect within it, presenting in its interior walls abrupt slopes in all directions, especially towards the north, in which they form almost vertical walls of approximately 500 meters elevation. The highest part of the rim is that which faces Calamba and Los Baños, which is broken into four peaks, the highest of which, according to our barometric observation, has an elevation of 1047 meters or, according to the plan of the Naval Hydrographic Commission, 1135 meters. This rim diminishes in altitude toward the west to 973 meters in the subordinate and conical peak which can be seen from the town of Santo Tomás and through which one can make the ascent of the mountain.

The northern slopes

The exterior slopes towards the north, especially their upper parts which are formed by a rocky wall and are completely inaccessible and covered with rachitic vegetation, are steeper than those

that lead to the other directions. And since in the west and south the slopes are much more gentle, although they may have deep narrow valleys and variable undulations, Mount Maquiling appears as if it were leaning toward Laguna de Bay, from which fact it undoubtedly gets its name.[4]

Along the shores of the great lake two small hills rise. One of them is that which we have already cited when we discussed the Alligator Lake inside it and the other is the Pansol, which is situated north of the highest peak of Maquiling.

We have already said that the hill which now forms the Manlilimbas Point has the form of a ring which surrounds the Alligator Lake and rises toward the north, in the same manner as the rim of the crater of Mount Maquiling. The hill of Pansol is dome-shaped and joins the high slopes of the principal mountain by an undulating ridge, called Lalakay Mountain.

The western slopes

The western slopes of Mt. Maquiling are very undulating and contain many secondary hills which are prominent in the middle slopes, and numerous in the lower slopes adjacent to the river, where erosion has acted on materials (tuff) which are softer than those found at higher elevation.

The eastern slopes

Towards the east the slopes are of even more complicated forms in the series of secondary hills which, parting from Mabilog, not far from the summit and following Bulalo, crosses the Tigas River and turns northeast towards the town of Calauan, forming the chain of Imuc and Calauan, which joins Maquiling with San Cristobal and Banahao. The Olila hill which is located on the other side of the river west of Alaminos seems, undoubtedly, to belong to the same class as those which we have mentioned and is likewise subordinate to Maquiling.

The slope at the left of the Cambantoc River presents also some secondary elevations which, joining together to form a ridge and end at the Tuluñgin Mountains near the lake.

Also, between the Dampalit and Molawin Rivers, there is a pronounced ridge which dips near Los Baños and rises anew along the shores of Laguna de Bay to form the elliptical nipple-shaped Mayondon hill and point.

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[4] Maquiling in the dialect of the region means inclined (leaning).

One may perhaps hazard the hypothesis that this ridge is connected with Talim Island or Jalajala Peninsula, as suggested by Pulo Bay, an intermediate point in this direction, thus correlating those volcanic foci with that of Maquiling. But the form of the bottom of the lake, as it can be conjectured from the few soundings taken of it, and with which we are acquainted, seems to belie this hypothesis, which, on the other hand, is reasonable.

GEOLOGY

General composition

Generally, Maquiling is a volcanic mass composed essentially of dolerites, its lower slopes being covered with tufas, peperinos and conglomerates, which are also volcanic.

The ashes, cinders, rapilli (lapilli and bombs?) and volcanic agglomerates, which must have been produced in the eruptions, giving rise to this massive mountain, have disappeared from the places in which they have formed or fallen, and have constituted the elements of tufas, peperinos and conglomerates surrounding its base now hidden beneath the water of Laguna de Bay and perhaps already covered with recent mud.

The spongy or lavic types of the dolerites can hardly be seen in the upper parts, the forms and structure of which have been conserved by their more compact component rocks, and can only be noted with certainty around Mayondon and Pansol hills which have been, as we shall see later, secondary or subordinate mouths, apparently of more recent origin.

Dolerites

The type of doleritic rock which we have frequently and constantly found is of granitoid texture and of porphyritic aspect, composed of blackish gray or pink magma with generally crystalline and brilliant feldspar, probably labradorite or oligoclase. Projecting from the union of these components are a few black points which are at times hardly perceptible, and at others visibly formed of augite crystals. According to Roth, who classified the samples gathered by Semper and Jagor, the dolerites also contain olivine and magnetite, but these minerals cannot be distinguished with the naked eye. They also contain little flakes of bronze-colored mica which in some samples are very dark.

In texture, this rock becomes at times coarser or more granitoid, but generally its grains tend to attenuate until they are converted

into real mimetites which Doctor Drasche called andesites. He describes them as seen under the microscope as follows: "In the rock is found a mass composed exclusively of plagioclase needles and numerous crystals of magnetite, cementing large crystals of amphibole and augite." According to the said geologist, these andesites have, to the naked eye, something of the structure of obsidian; but all the rocks which we have found, besides the lavic rocks which we shall describe later on, are either granitoid or sandy or compact, and only in the mimesitas which form the wall or crest of the highest peak of the mountain have we seen some, although scarce, scoriaceous cavities. He adds, "Further on, I found small grey pebbles of fine-grained and porous rock with several small crystals of olivine; the ground mass of the rocks, seen under the microscope, shows the surprising aspect of a fine and regular fabric of plagioclase and amphibole needles, all these crystals being cemented with colorless and amorphous mass. In certain places round grains are also seen, which, by their structure, seem to be products of vitrification, and square pieces of magnetic iron." [5]

Basaltic and trachytic types

In some cases the mimesitas have a tendency in many places to become still more compact, losing their gritty structure and turning into real basalt or basanites, like those which are found in Taal Volcano; in other places, because of the predominance of feldspar and the appearance of perfectly visible amphibole, the mimesitas can be taken for true trachytes, inasmuch as the feldspar, on certain occasions, has an appearance similar, if not identical, to pumice, which is well characterized in the tufas at the base of Mt. Maquiling.[6]

Phonolitic type

The banded samples found in abundance in the interior of the crater and in other places are very odd, because when their structure is very fine they constitute real phonolites, which we consider as belonging to the trachyte family.

Trachydolerites

We could perhaps more appropriately call the rocks which constitute Mt. Maquiling grey stones (trachydolerite). It may be observed

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[5] See fig. No. 1 of plate D., Vol. VII of "Boletín de la Comisión del Mapa Geológico de España."

[6] Doctor Drasche calls trachyte a rock which he found on the way from Calamba to Santo Tomás, that is to say, the foot of Mt. Maquiling, and which has come from its slopes.

that those rocks which seem oldest on account of their position are those which come nearest to the trachytic type, the younger rocks resembling basalt or dolerite, including those rocks of effusive character found in Pansol and Mayondon.

The same thing can be said of the eastern part of Suñgay where the rocks resemble those of Maquiling very much, although they have more phonolite characteristic, so to speak. This fact and the exterior form of the Suñgay Mountain make one suspect that it is older than Maquiling.[7]

Effusive types

In the hills of Mayondon and Pansol and in certain limited areas, as in the summit of Tuluñgin, there are spongy or scoriaceous rocks of more effusive type and younger than the ones cited. In their exterior they present a red or brownish color due to the oxidation of the iron salts which they contain, but in their interior, in the fracture, they show in their scoraceous cavities a black and compact paste bespattered with minute feldspar crystals, hence constituting real effusive basanites.

Tufas and peperinos

All the tufas which cover and surround the slopes of the mountain are very compact and exactly like those which come from the left margin of the Pasig river in Guadalupe and which are used for construction purposes in Manila. They are generally of fine grain, yellowish or brownish grey color, and form benches which seem to adapt to the undulated forms of the fields which they cover, being composed of a clayey cineritious (ash-colored) paste with pieces of "rapilos", principally pumiceous and feldspathic. In many places these tufas are transformed into real peperinos or conglomerates of pebbles almost exclusively of basalt or dolerite.

PRESENT VOLCANIC EMISSIONS

All the foregoing rocks have been transformed and metamorphosed in certain places by numerous manifestations of the same volcanic action which produced them, and, therefore, this igneous subterranean action cannot be considered as completely extinct, in spite of the significant signs of relative antiquity of the extinction of the principal focus of the mountain.

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[7] We have not discussed in detail Mt. Suñgay, which we have briefly and partly visited, because D. José Centeno, who was in charge of the careful study of Taal Volcano, which should include the hydrographic region of the Bombon Lake, will discuss it in more detail. We have outlined however, the limits of the tufas of its flank, in order to correlate it with Mt. Maquiling.

Let us, therefore, examine the phenomena which are produced in these numerous manifestations and which can all be included under the name of volcanic emanations.

Natugnos

One of the most remarkable of these emanations is undoubtedly that which is found in the place called Natugnos. In that place, at the right bank of the upper course of the Molawin River at an elevation of about 310 meters, and not far from its bed, there is a small lake having a diameter of about 20 meters, in the proximity of which a faint sulphurous odor can be perceived. Inside the small lake one can see leaden grey muds in active ebullition the bubbles from which burst at the surface, with a peculiar sound and throw forth at the borders and out of them a semi-liquid and pasty mud, the temperature of which reaches 84°C. This bubbling activity must have had some periods of increased intensity, because from the margin of the lake to the Molawin creek a wide trail of deposits and concretions (*moyas*) with rough surface similar to that of the pasty lava flow of active volcanos can be seen, as if the whole lake had flowed over the sides in the direction of the slope.

In the vicinity of this principal lake there are many others of smaller size, some like wells and simple mouths of smoke, always muddy, from which vapors gush at high tension and in which the bubbling mud shows different colors, such as red, yellow, brown and sometimes, although seldom, pure white.[8]

Concretions

The nature of these *moyas* or deposits and concretions, formed by the mud of the lakes, are consigned, from the geologic point of view, in the description of the samples collected in the field, which we include at the end of this article; but, furthermore, we deem it useful to insert here the minute and precise description of these substances by Roth from a chemical point of view, based on the samples collected by Semper and Jagor in their travels. "There are places in which the rocks has been transformed by iron oxide into a gray

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[8] Here is a description of this place written in 1739, which is kept in the archives of the Convent of the Franciscans in Manila and to which the majority of the travelers, who have cited it, refer: "There is a hill called Natugnos on the top of which is a lake about 400 square feet, in continuous movement on account of the intense vapor that it emits. The mass in it is an extremely white earth which, with the force of the vapor, now and then rises a yard or a yard and a half in queer forms and fall in small pieces upon coming in contact with the surrounding cold air." (Estado geografico etc., by the PP. Franciscanos. Binondo, 1865).

or yellowish gray mass of clayey nature, brittle and with cavities or crevices which contain opal. In the surface of the rock the water [9] has deposited a crust the exterior part of which is wavy. The bluish gray deposits of tufas [10] of hydrated silica with small quantities of basic sulphate of iron oxide alternate with other yellowish-red strata, rich in iron. The bluish gray color comes from a mixture of fine powder, which can be verified by testing the samples with acids and alkali. The tufa has, according to this test, a composition similar to that of the siliceous tufa of Iceland which has been studied by Bickel, a fact which proves the similarity of the phenomena or processes which have occurred in both places. The said rock, when decomposed and it has a yellowish grey color, gives gypsum when placed in water; the reddish brown variety when tested with hydrochloric acid reveals a great quantity of sulphuric acid, and in both varieties iron is found as acid sulphates.

Comparison with those of Tiwi and Iceland

The similarity which Roth establishes between the phenomena which produces these concretions and the phenomena which produces those of Iceland would make us believe that they are also similar to those which formed the siliceous cones of Naglagbong in the town of Tiwi, Albay, which we had the opportunity of describing in the "Emanaciones Volcánicas de Malinao", and which we compared also with those of Iceland. However, the white cones of Naglagbong come from the water of saline and transparent lakes, the scale-forming elements of which are found in exclusively chemical solution, while the siliceous *moyas* of Natugnos come principally from waters, which, although they contain also elements in solution, contain mud or *moyas* in mixture or in dilution. Aside from this, in Naglagbong the abundance and the beauty of the siliceous deposits should be attributed essentially to the salts contained in sea water, while in Natugnos we cannot nor is there any necessity of invoking such cause, since the presence of sulphurous vapors in the fumaroles acting on the doleritic rocks suffices to explain the formation of the *moyas* and the relatively scant quantities of silica which their concretions contain. These concretions, without doubt, on account of the fumaroles, have acquired neither the growth nor the predominant siliceous element which they acquired in Naglagbong.

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[9] He should say the volcanic mud of the lake.

[10] Tufaceous sinter, not volcanic tufa.

Only by the more ferruginous and clayey nature of the deposits of Natugnos could we perhaps compare them with those of the silicic-ferruginous springs of Naglagbong which produced the "cono-rojo" (red cone) but always with the essential distinction that on the latter, salt waters have intervened, although probably at a much lower degree than they have in the springs of the "conos blancos" (white cones).

Lupang Puti of Los Baños

East of Natugnos, at an elevation of 374 meters and already in the water shed of the Maitim River, there is a place called Lupang Puti (white earth), in which the inhabitants dig small wells, tunnels and large trenches in order to obtain "bianquettos" (white bricks) which are used for whitewashing the buildings in the province and in Manila. Two places, called Matanda (old) and Bata (young), are preferred, for these are small exploitations and in them the rocks are whitened or kaolinized by the action of the fumaroles, which, properly speaking, no longer exist, although it may be noticed that in many places the ground is still very hot. This fact proves that vapors still emit in the interior at a low tension and scatter in or impregnate the crevices and the interstices of the rocks without manifesting themselves in the form of real fumaroles.

The clays, which are perhaps selinitic, are not all perfectly white in these places but are blue, gray, red or yellow in certain points, with pure, uniform or porphyritic tints which do not disappear in kneading. These properties make them appropriate for painting and making stucco for marble and colored jasper imitations.

Bitin

In the barrio of Bitin of the town of Bay, near the Pinquian creek and at an elevation of 240 meters, there are also very intense volcanic emanations in the form of solfataras containing the corresponding "bianquettos", which the natives exploit for whitewashing, as in Lupang Puti, Los Baños.

Lupang Puti of Bay

In this place the volcanic activity is more varied than in Natugnos. In these place which the natives also call Lupang Puti, a short distance south of Pinquian Creek, there is a vast barren place in which many fumaroles, some mild and others strong, issue, producing the hissing sound of gases which pass from a high to a low pressure. Wherever the ground is touched, the temperature is high and

in the vicinity of the fumaroles it reaches more than 100°C. All the ground is covered with sulphur deposits of variegated color, the most outstanding of which being white, red and yellow, and with beautiful concretions of sulphur, basic sulphate of iron and of perfectly white and yellow featherlike alum crystals.

Pinquian Creek

Its activity extends north through several mild fumaroles as far as a small tributary of the Pinquian, near which the energy of these fumaroles recrudesces considerably. In fact, some fumaroles are found with mouths of more than 80 cm. in diameter, which produce true eruptions of water and boiling yellowish liquid mud which are projected to a short distance, producing concretions similar to those in Natugnos and, in addition, sulphur and alum crystals.

Pinagrialan

Lastly, to the NE of the municipality of Santo Tomás, at an elevation of 253 meters, on the western slopes of Maquiling, there is a place called Pinagrialan, in which another solfatara is found with phenomena and concretions similar to those of Bitin and Puting Lupa, and in which some communal development of the white earth is being made for whitewashing buildings. We need not, therefore, dwell upon its description.

Hot springs

Let us now proceed to describe the other kind of volcanic manifestations which consist of numerous hot springs found on the flanks of Mt. Maquiling. We can and must consider them as the result of interior fumaroles which, instead of coming out, expend themselves in raising the temperature of the waters of the subterranean streams and increasing their solvent power towards certain substances. The hot springs are, so to speak, the last vestiges of the activity of the volcanic foci.

Aguas Santas (Holy Waters)—its history

The most important springs and also the best known for their medicinal properties are those which come out in the town of Los Baños and which were already known by the natives in the time of the conquest and called Mainit by them, which means hot. In 1593 the Franciscans built in this place a small sanatorium, but hav-

ing had some misunderstanding with the Augustinians, who formerly were in charge of the spiritual administration of the town of Bay, to which Los Baños depended, they, in order to obviate further misunderstanding, obtained its formal concession in 1627 and in 1671 erected a hospital and a chapel named Aguas Santas. A few years later, the Royal Patronage took possession of this health establishment and the State took charge of it till 1727, when it was destroyed by fire. This condition of things remained until the arrival of General Moriones, who proposed to restore it, and for this purpose resorted to public charity and actually built, with the proceeds of the collections, three hothouses, and edifice named "Pabellón del General" (The General's Pavilion) and another of large proportions intended for a hospital, which has never been completed.

Temperature and analysis

The waters which were used in the old establishment of the friars were conveyed through a short conduit of masonry, which still exists. They leave the conduit at a temperature of 91.32°C., and fall into the ruins of an old piscina constructed along the shores of the lake, here the temperature is reduced to 83.75°C. From the piscina the waters, still steaming, flow and mix with those of the lake.

In an analysis of these waters made in Manila in 1787 by a Frenchman,[11] the exterior and organolephic character of the waters are described with sufficient exactness, but a much lower temperature than that which we have verified has been noted down for the water of the spring.

The descriptions says thus: "The multitude of springs which come out near the town called Los Baños have the same origin, but they differ in temperature. The principal spring has a temperature of 67°, according to Reaumur thermometer, while the spring of minimum temperature has 29°. The water is clear, almost crystalline white and its odor is somewhat like that of lye, but its taste when fresh is not unpleasant and one can scarcely notice its salt content. When the water cools due to the loss of a great amount of air it becomes tasteless." In referring to the composition of the water, the description continues as follows: "The analysis made by reaction as

[11] Estado geografico de los PP. Franciscanos, etc.

well as by evaporation has given the same result. Six lbs. of water have given 101½ grains of residue in this way:

Sea salt, calcareous	60 grains
" " of magnesium	2½ "
" " common	26 "
Selenites	4½ "
Iron	½ "
Calcium, clay	8 "
	101½ "

In 1877 the study of these waters from the medical point of view was entrusted to the military physician Doctor Franco and his report was published in one of the Manila periodicals. According to said report, the water on leaving the spring has a temperature of 89°C.

Supposing that this temperature and that of the Frenchman were taken accurately, since there is no reason to doubt it, we may surmise the remarkable fact that the water which in 1787 had a temperature of only 83.75°C. (67°R.), had 89°C. in 1877 and 91.32° in 1881, that is to say, the temperature of the water is rising.

If this fact could be duly verified, it might lead us to some important geologic conclusion.

In the said report of Doctor Franco the result of the analyses of the waters made by the pharmacist D. Leon Guerrero is also inserted. Here are the results:

From 1,000 grams of water a residue of the following weight and composition was found:

Sodium chloride, $NaCl$	0.60 gram
Calcium chloride, $CaCl_2$	0.26 "
Magnesium chloride, $MgCl_2$	0.04 "
Sodium sulfate, Na_2SO_4	0.05 "
Calcium sulfate, $CaSO_4$	0.10 "
Magnesium sulfate, $MgSO_4$	0.03 "
Silica	0.02 "
	1.10
Loss	0.04 "
Solid residue	1.14 "

Besides, in the 1,000 grams of water, 0.02 cubic meters of atmospheric air and traces of hydrosulphuric (sulfhidrico) and carbonic acids are found, and also traces of ferrous salts, phosphates and undetermined organic substances.

The same Doctor Franco, who calls these waters *salino-clorurradas-termales*, prescribes them as proper remedies for the following ailments: internally for malarial fevers, kidney and spleen infarcts (obstructions), diarrhea and chronic dysentery, atony (weakness) of the digestive tract, gastritis, chronic hepatitis and other afflictions; as baths or sudatory for rheumatism, gout, muscular atrophy, atonic ulcers and old wounds.

Aside from these springs there are also in Los Baños and in certain parts of Calamba and Bay a multitude of thermal springs of diverse temperature and probably also of varied composition, since in the report of Doctor Franco, the following composition which was determined by the pharmacist who made the former analysis is given for the waters of a spring the location of which is not ascertained:

Ferrous carbonate	0.47
Calcium carbonate	0.45
Magnesium carbonate	0.17
Calcium sulfate	0.49
Magnesium sulfate	0.35
Sodium chloride	0.23
Magnesium chloride	0.15
Silica	0.38
Undetermined substances	0.40 (?)
Loss	0.20
Solid residue	3.29

Tadlac and Sucot

In the neighborhood of the hill in which the Alligator Lake is located we have seen many hot springs, some in the margins of the Tadlac Creek with a temperature of as high as 49°, and others to the SSW, in a place called Sucol, with 88°, temperature and of very ferruginous character, judging from the color of the deposits which they produce and, above all, by the astringent taste of the waters.

Mayondon

At the base of Mayondon Hill several springs with 57° and 40° temperature are also seen. The waters of these springs have hardly any taste and do not produce concretions.

Bacon

Likewise, in a place called Bacon, located near the road to Calamba, several springs can be seen emitting bubbles which cannot be produced by water vapor, as the temperature in the middle of the

spring is only 58°. Beside this spring is another with only 44° temperature.

In the same place, on trying to pry a hard crust which has been deposited apparently by an exhausted spring, a dart of vapor gushed up with force and blew the hammer off our hands and reopened immediately a spring with a temperature of 95° which probably would cool off gradually.

Pansol

In the neighborhood of Pansol Hill, especially towards the west, numerous springs flow, all of which are almost always ferruginous and more or less thermal, the temperatures which we have verified varying from 33° to 47°C. These springs unite with a small stream which comes from another spring called Tigbi, at a higher elevation, and flow down the hill into the lake.

Bucal

In the town of Calamba, alongside the road which leads to Los Baños, a depression is found in a place called Bucal [12] which has been formed by the meeting of several springs of moderate temperature, ranging from 32 to 36°. Towards the lake these springs form a copious stream which is utilized as motive power for the sugar mills situated there.

Others

Lastly, between the towns of Los Baños and Bay and between those of Bay and Calamba, in the plain and in places of medium elevation, likewise a multitude of more or less thermal springs flow, the detailed enumeration of which would not only be tiresome but fruitless. It is sufficient to know that they exist along the Cambantoc, Lalaog and Tigbi rivers and in the plain of Calauan.

SUMMARY AND CONCLUSIONS

Summing up the facts and the circumstances which we have just enumerated, one may conclude in the first place that Mt. Maquiling, because of its orographic forms and component rocks, is a recent volcanic mountain in the geologic sense of the word, but, on the other hand, the absence of true effusive rocks in the interior of its crater and in its upper flanks indicate that it has been extinct for a relatively long time, as confirmed by the tradition which is not very ancient

[12] Tagalog word for fountains or spring.

in these regions, and by the old vegetation in the crater and slopes of the mountain.

The existence of the Maquiling and Pansol hills and above all that of the Alligator Lake and the effusive rocks which compose them, show also that after the beginning of the activity of the principal focus of Maquiling, and perhaps after its partial or total extinction, other foci of less intense activity subordinated to the principal focus have appeared, the last of which is, without doubt, the anular craterlike hill of the Alligator Lake. This lake aside from the aforesaid effusive type of its rocks, still retain the characteristic rapilli, cinerites, and peperinos of recent activity.

Probably also, during the interval between the two events, that is between the beginning and extinction of the volcanic activity of Mt. Maquiling, a gradual rise of the adjoining territory including the volcano itself began, because it seems very credible, to us at least, that the mantle of tufas which surround the Maquiling is not of subaërial formation but has been deposited at the bottom of a sea which was not very deep and was somewhat stirred, if one is to judge by the big and small haphazardly inter-mixed but perfectly stratified pieces of tufa which composed the volcanic "peperinos" (consolidated volcanic ejecta) and conglomerates of the mountain which do not only exist at the base of Mt. Maquiling, but extend over the southern shore of the lake and the left bank of the Pasig River as far as the outskirts of Manila. Otherwise, it could not be satisfactorily explained how the mere production of volcanic ash carried away by the winds and waters, with the aid of consequent corrosions, could have produced such uniformity and relative compactness of the texture and structure of the tufas and peperinos and such uniformity of the strata, separated by true beds of subaqueous formation.

We believe also that, in favor of this point of view, many other reasons such as the extension and composition of the tufaceous strata of Central Luzon could be adduced, but we do not indicate them here because they would have to be related to other foci which bound, so to speak, the great central plain from the Arayat to the Banahao Mt.

The extinction of the exterior manifestations and, so to speak, effusive activities of the secondary foci of Mayondon, Pansol, the hill of the Alligator Lake and several others in other parts of the mountain, did not cause the sudden extinction of the central interior activities. Much weakened to produce new ruptures and powerful emission of gases and liquids and, we might say, pasty rocks, they limited themselves to issue through the weakest part of former ruptures and

through those nearest the principal and secondary foci or at least through parts that offer the least resistance. These exterior manifestations also issued vapors charged with acid and corrosive substances which metamorphosed the volcanic rocks that have already cooled off, producing in them varied effects. The vapors sometimes succeed in reaching the surface to form solfataras, and at other times merely raise the temperature of the subterranean waters, saturating them with vapors and corrosive substances and making them able to dissolve other new substances contained in the rocks which they encounter in their subterranean passages. These passages likewise become metamorphosed in a greater or smaller zone.

The manifestations of these volcanic phenomena can be plainly seen in Natugnos, in the Pinquian stream, in Pinagrialan and the two Puting Lupa, the principal and dominant points of the solfataric activity, and in the numerous and very hot springs which issue along the shores of Laguna de Bay, the weakest of these solfataric manifestations.

Can we, therefore, consider Maquiling as a completely extinct volcano?

Unfortunately, there is no sign by which we can be sure of the true extinction of a volcanic focus, in the sense that no paroxysm similar to that which produced the volcanic mass itself will recur. While its external manifestations of igneous and gaseous emanations are still manifest with certain degree of energy, as they are in Maquiling, we believe that we cannot or should not consider a volcano completely extinct. It could be said that Maquiling is a volcano which does not produce true eruptions today and that the exterior of its crater is completely extinct, but we must not forget that Spartacus camped with 10,000 gladiators in the interior of the crater of Vesuvius which was then covered with beautiful vegetation, and that today this crater is full of other substances and is the scene of another kind of events which are more natural and certainly had not been forseen by Spartacus and his gladiators.

ROCKS FROM MOUNT MAQUILING AND SOME FROM SUÑGAY

MOUNT MAQUILING

Blackish granitoid dolerite.

Granitoid mass, composed of grayish black magma with a great quantity of feldspar and a few hardly distinguishable points of deep black color in the gray mass, which are probably augite or magnetic iron.—Cascade of the river Dampalit in Los Baños.

Reddish granitoid dolerite.

Like the above-mentioned rock, with a light red back-ground spattered with plainly visible black points and small white feldspar crystals.—From the same locality.

Whitish mimetite.

Compact mass, grayish white, very adelogenous (uncertain composition), with vesicles which contain iron oxide.—From the same place.

Gray granular dolerite.

Bluish gray mass, granular, with brilliant white and silky crystals of feldspar, black crystals of augite and a few small laminae of black mica.—Bucal, Calamba.

Recent tuff.

Hydrothermal deposits, somewhat siliceous.—From Bacon, Los Baños.

Reticulated siliceous tuff.

Tabular and reticular (hydrothermal) deposits.—From Bacon, Los Baños.

Reddish basaltic lava.

Scoriaceaus mass of reddish color, showing in the besicles along fractures, a black ground mass with small white crystals which constitute a true basanite.—From Pansol Mt. in Los Baños.

Lavic basonite.

Like the former, less scoriaceous and decomposed.—From the same place.

Basaltic spongy lava.

Identical with that found in Pansol.—From Mayondon Hill, Los Baños.

Whitish granitoid dolerite.

Whitish mass, almost doleritic. Transito or mimetite.—From Natugnos, Los Baños.

Scarlet siliceous kaolin tufa (moya).

Clayey mass, blood red, brittle, with tubular cavities, some with resinous and opaline quartz; covered with rugose surface in the form

of brown gray crust composed of superimposed layers of iron oxide with kaolin and silica.—From Natugnos, Los Baños.

Yellowish siliceous kaolin tufa (*moya*)

Similar to the above-mentioned rock.—From the same place.

Resinous tuff

Tubular, reticular siliceous mass, stained with yellowish and red kaolin—From the same place.

Yellowish red earthly tuff (*moya*)

Argillaceous mass in red and yellow bands, between which are noted efflorescence of white kaolin resembling minute stalagmites.—From the same place.

Grayish volcanic mud (*moya; trass*)

Fine argillaceous mass of uniform gray color, appropriate for painting purposes.—From the same place.

Red volcanic mud (*trass or moya*)

Argillaceous mass, reddish, with tiny white dots which persist even after kneading, producing porphyry-like pieces.—From Lupang Puti, Los Baños.

White volcanic mud (*kaolin*)

Used for whitewashing buildings.—From the same place.

Semidecomposed gray dolerites

Light gray doleritic mass with fissures stained with iron oxide. —From Lupang Puti (Pinquian Creek) in Barrio Bitin, Bay.

Kaolinized dolerite with sulphur

More whitened than the above, with superficial deposits of sulphur.—From the same place.

Gray fibrous wacke

Much decomposed dolerite mass with fibrous structure very similar to pumice.—From the same place.

Kaolinic wacke.—With tinted alum .... idem.
Wacke with concretions of sulphur .... idem.
Kaolinic wacke .... idem.
Tufaceous ferruginous wacke .... idem.
Tufaceous kaolin with iron oxide (*moya*) .... idem.

Fibrous wacke with sulphur .... idem.
Spongy kaolin with sulphur and alum .... idem.
Kaolin with iron sulphate .... idem.
Plume alum .... idem.
Alum tinted yellow .... idem.

Reddish mimetite

Adelogenous dolerite of sandy appearance, fine and massive, with some scoriaceous cavities in the mass.—Highest peak of Maquiling.

Reddish dolerite

Very similar to that of Dampalit River, although somewhat more massive and less granitoid.—From Bisoag creek of Santo Tomas.

Banded dolerite

Alternating bands of blackish gray and reddish dolerite which gave the mass a slaty or phonolitic appearance.—From the same place.

Augitic dolerite

Whitish semifibrous mass with some similarity to pumice, bespattered with numerous crystals of augite, some as long as 5 millimeters. —From the same place.

SUÑGAY MOUNTAIN

Trachydolerite

Gray mass with dots or small white feldspar, crystals, black acicular augite crystals and greenish black lamellar hornblende crystals. —Gonzales Peak.

Banded trachydolerite

Gray fanerogenous (definite composition) mass in compact layers separated by others of whitish color.—Near the peak.

Domita or galenaceous

Yellowish gray, argillaceous, semidecomposed mass.—Near the peak.

Some loose lavic rocks which might have been ejected by the Taal Volcano have also been found.

Manila, September 10, 1882.

COLLEGE AND ALUMNI NOTES

The first semester began on June 7 with a total enrollment of 479 students, of whom 148 were new. These figures do not include the registrants at the Rural High School, which totaled 132. At the opening exercises in the morning, Dr. R. B. Espino, head of the Department of Agricultural Botany, spoke on behalf of the faculty; and Mr. Remberto Z. Ver represented the student body. Dean B. M. Gonzalez welcomed the new students.

The faculty of the College was reënforced by the following recent additions: Mr. Emilio M. del Rosario, formerly of the School of Forestry faculty, assistant professor of English; Mr. Julio P. Sevilla, B. S. C. E., '36, assistant in engineering; Mr. José K. Demeterio, B.S.S.T., '37, assistant in agricultural chemistry; and Mr. Gavino B. Rotor, Jr., B.S.Agr., '37, assistant in agronomy.

Recent promotions at the College of Agriculture include Dr. Jaime Laico, director of the U. P. Los Baños Infirmary, with rank of assistant professor; Mr. Alfredo V. Yñiguez, from chief clerk to chief, administrative division of the College; Mrs. Mamerta Manahan Ylagan, from assistant analyst to analyst, experiment station, and pharmacist of the Infirmary; Mr. Teodosio Buenaventura, from instructor to assistant professor of history and Spanish; and Mr. Nazario Pidlaoan, from assistant in agricultural chemistry to instructor.

At the faculty conference which was called in Baguio by the President of the University of the Philippines from May 17 to 22, the delegates from the College of Agriculture were Dean B. M. Gonzalez, Dr. Anastasio L. Teodoro, Dr. F. O. Santos, Dr. L. B. Uichanco, Prof. Teodosio Buenaventura, Prof. Elvie Fraser, Dr. N. Galvez, and Mr. Jesus de Guzman.

The sixth rural life institute was held at the College from April 5 to 10, with an attendance of twenty. Varied subjects were treated at this institute, including vegetable raising, preservation of fruits and vegetables, ham making, soy-sauce manufacture, fish culture for inland communities, poultry raising, co-operatives, seed selection, and balanced diet.

Dr. Miguel Manresa, assistant professor of animal husbandry, made a two-month trip to India, from March 30 to June 2, 1937, for the purpose of studying the live-stock situation in that country. His itinerary covered Madura, Trichinopoly, Madras, Hosur, Bangalore, Mysore, Bombay, Agra, Delhi, Cawnpore, Lucknow, Allahabad, Calcutta, and southern Burma, in which he had occasion to look into the operation of five agricultural colleges and of a large number of government and privately owned dairies.

Dr. G. O. Ocfemia, head of the Department of Plant Pathology, was sent to Davao at the request of Mr. H. T. Edwards, of the U. S. Department of Agriculture, in order to investigate an unknown new disease of abacá, which seemed to threaten this important crop in that province. After spending sometime on the field, Doctor Ocfemia brought back with him infested material for more detailed study.

Dr. F. O. Santos, head of the Department of Agricultural Chemistry, spent a month, from April 8 to May 9, on a trip to Leyte, Lanao, Cotabato, Davao, Zamboanga, and Jolo, in order to start a co-operative program of study on the plane of nutrition of the inhabitants in eastern Visayas and Mindanao.

Dr. José B. Juliano, assistant professor of agricultural botany, explored the Bicol Peninsula from May 10 to 16 for experimental material on the different abacá varieties.

Mr. Julian B. Banzon, instructor in agricultural chemistry, and Mr. Jesus de Guzman, assistant in horticulture, have recently been appointed University fellows by the Board of Regents. Mr. Banzon is being sent abroad to take up advanced work on the utilization of agricultural products from a chemical standpoint. Mr. De Guzman will pursue graduate work in rural education and horticulture.

Lieut. Ricardo Buhay, P. A. (Res.), has been given charge, as assistant commandant, of the Los Baños unit of the R.O.T.C., relieving Capt. Pablo Suarez, P. A., who is now stationed in Manila. Lieut. Buhay, having lived in Los Baños, first as a student and later, for a number of years, as an instructor and secretary of the School of Forestry, is not a stranger on the campus.

The Honorable General Secretary of the Bureau of Human Heredity, London, has designated Dr. J. M. Capinpin of this College, Philippine correspondent and co-operator for research work in human genetics.

A party of municipal presidents of Tarlac province, headed by Gov. José Urquico, visited the College on April 21, where Dean Gonzalez personally conducted them through the laboratories and farms of the institution. The party was escorted to the Campus by Gov. Juan Cailles and other provincial executives of Laguna.

Mr. Quintin A. Eala, '27, who had been librarian of the College for ten years, since November 16, 1926, resigned May 24, 1937, in order to accept a position in the scientific library division of the Department of Agriculture and Commerce. Mr. Engracio E. Basio, '31, instructor in animal husbandry, has been designated acting librarian.

Mr. E. K. Ongsansoy, instructor in agricultural engineering, resigned June 1, in order to enter the service of a private firm in Manila.

It is gratifying to record that our sister colleges of the University of the Philippines in Manila are copying the educational example set by Los Baños thirteen years ago when they recently decided to establish, under the U. P. High School, an elementary school in order to take care of the sons and daughters of their faculty members. The Maquiling School, which conducts instruction in all elementary grades, from the kindergarten to the seventh, has been in successful operation on the campus of the College of Agriculture since May 5, 1924. The present enrollment of this school is 56.

IN MEMORIAM

ENRIQUE MARASIGAN BAUTISTA, B.S.C.E., '26, University of Washington. Born Calaca, Batangas province, July 16, 1902. Instructor in agricultural engineering, College of Agriculture, since August 25, 1930. Died at Los Baños, Laguna province, June 13, 1937.

ERRATA

THE PHILIPPINE AGRICULTURIST, VOL. XXVI, No. 1, JUNE, 1937

On page 73, after fig. 138, insert:

139. Portion of a transverse section of the blade near the margin. × 85.

PLATE 20

Fig. 140. Portion of a transverse section of the leaf sheath near its midrib. × 85.

141. Photograph of a thin film of "kiskisan" rice bran. Slightly reduced.

142. Portion of a transverse section of the mature intercalary meristem. × 85.

143. Photograph of a thin film of sieved "kiskisan" rice bran. Slightly reduced.

A NINETEENTH CENTURY SPANISH DIPLOMAT'S VIEW OF PHILIPPINE COLONIAL POLICY

We are reproducing below an English translation of a passage from volume 3 of Sinibaldo de Mas' *Informe sobre el estado de las Islas Filipinas en 1842* (Report on the state of the Philippine Islands in 1842), which was originally published in Madrid in 1843. Not only because of its intrinsic historical merit, but also because it is an example of how, even late in the already decadent period of Spanish colonial administration of the Philippines, Spain was not without enlightened statesmen who could view the Philippine question in its broader aspects, the paper deserves a careful perusal. Certain of the points brought out in this century-old report are remarkable for their analytical keenness and accuracy in forecasting later events. Some of the difficulties now confronting the islands might perhaps be better understood and met when taken with due regard to De Mas' findings. It is refreshing to note that modern problems which we sometimes regard as new really date back to an older period. If Spain had heeded De Mas' suggestions, the course of events which are just now occurring might have been accelerated and the current chapters of Philippine history written about a century earlier.

After a few years, when the population will have been sufficiently prepared, there shall be created an Assembly of the representatives of the people which shall hold meetings in Manila for two or three months during each year, wherein public affairs shall be dealt with, especially those related to taxation and appropriation. After a period of such political training, our [Spanish] Government can then confidently withdraw, assuring itself first that there remains established some Constitution analogous perhaps to those of Europe, with a royal prince at the head who shall be selected from among our [Spanish royal] *infantes*.

My work is done. Which of the plans described above would be more equable or convenient to adopt, I do not feel called upon to recommend, much less to propose.

I will, however, add a page to express my opinion as a private citizen of the Spanish nation. If I were to choose, I would vote for the last. I am not aware of any benefit that we get from the colonies: depopulation, decadence of the arts, and public debt come to us largely because of these. The interest of a state, in my opinion, demands a large and well-educated population; and I do not refer merely to literary and political education, but to a general one which makes every one faultless in his occupation, that is to say, one that would

make of a cabinet-maker, weaver, or smith the best possible cabinet-maker, weaver, or smith. In the present century, the larger or smaller number of engines is an almost certain thermometer by which to judge the might of empires.

A colony cannot be useful unless it fulfills some of these three objects. Convert it into a tributary state in order to increase the revenue of the sovereign (as Holland has done through a compulsory and exclusive system); establish it as a second country and place for emigration of excess population (as are more particularly Australia, Van Diemen [Tasmania], and New Zealand); and, finally, secure in it a market to absorb national manufactures (which is the principal goal of modern ventures overseas.) As to the first, we have already seen that the Philippines is a poor source [of revenue] and will be for a long time, and I shall not be surprised if, on the contrary, before finally losing it, it should cost us several millions. For the second object, colonies are unnecessary, inasmuch as we have no excess population to unload. And for the third, they are useless, because we lack manufactures to export. Barcelona, which is the most highly industrialized place in the Peninsula, has not the least form of direct communication with the Islands; all that is sent there from Cadiz consists of a little paper, oil, and liquors. Were it not for tobacco, and for the incoming and outgoing passengers, one or two ships a year would have been sufficient to take care of the commercial transactions between the two countries. Some will point out, however, that if nowadays our industries are undeveloped, these might within a few years reach the level of the most advanced country and, hence, count on the Philippines as a rich market. . . . Separation would not thereby stand in the way of these advantages; the commerce of England with North America is now a hundred times more than when the latter was subject to her laws.—That if at present we have not an excess of population, we might have it within a century. . . . By that time the Philippines itself would not be short of inhabitants and it would be necessary to emigrate to Marianas.—That if we should leave the country, the Christian religion would soon be lost, at least among the natives. . . . As I am not a missionary, I must confess that the objection has no strong appeal to me, and I believe that God is sufficient by Himself to take care of the salvation of His people.—That in view of the difficulty of defending that country, divided as it is into many islands and because of its other peculiar conditions, there can be no doubt that, with an excuse or without one, it would

fall into the hands of England, France, or Holland, from which up to now it has been safe on account of the respect they have for Spain; and that, if not into the hands of European powers, it would fall into those of Asiatic nations, especially China, under whose yoke the islands would have been groaning for years now if Castilian soldiers had not given battle to ward it off; otherwise, it may fall into the hands of the growing states of New Australia, Van Diemen [Tasmania] and New Zealand. . . . On this principle, we should constitute ourselves into errant knights for all helpless countries; when we shall have reached this stage, the Spaniards established in the country would always have recourse to returning to their home land.—That Spain has spent in these islands more than 300 million silver dollars, in addition to countless lives, and it is but just that we be reimbursed. . . . We have likewise spent much in expeditions to the Holy Land, but we have no thought of recovering that.—That with its own king or government the Filipinos would have to pay heavier taxes than are now required of them, as may be easily proved by the examples of free nations, not excepting Spain itself. . . . The same has happened with the Greeks who are now poorer and who pay more than before the insurrection [1]; nevertheless, they are not recalling the Ottomans. And if the Filipinos should miss us some day, they would then remember our times with thankfulness and would regret the ingratitude that many of them have shown us.—That the sins of some should not fall on the heads of all; that those who desire the downfall of our dominion are the short-sighted, the recalcitrants, and the covetous; and that if we should put the question to the inhabitants, one by one, as to whether they wished us to go or to stay, 90 per cent would vote for the latter. . . . Granting that this is true, I am not entirely convinced, because I know that Turkish women deem their lot a very happy one and pity their European sisters, and this is no reason to believe that their condition is enviable, because, if they knew no other kind of life than that of the harem, they would think in this wise.

In conclusion: if we kept the Islands for the love of the islanders, we would be losing time and opportunity, because gratitude is at times found in individuals, never in nations. In any case, owing to our love, we are committing an anomaly, for, how could we reconcile the fact that we esteem liberty for ourselves and at the same time wish to impose our authority on alien peoples? Why deny others the advantages that we want for our own country? On these principles

[1] The War of Greek Independence, 1821-1829.—L. B. U.

of universal morality and justice, and because I am convinced that in the midst of the political events now obtaining in Spain, the state will neglect that colony; none of the measures I am proposing for its conservation will be adopted (this is my conviction); and it will emancipate itself through violence, with a great loss of property and life of Spaniards, Europeans, and Filipinos. I believe it would be by far easier, more convenient, and more glorious that we earned the rewards of the work, by forestalling the event through generosity. Hence, foreign writers, who have heaped such calumny on our overseas governments, writers of those nations whose hunger for colonies is never satisfied, would at least have occasion to say this time: "The Spaniards crossed uncharted and distant seas, extending the domains of geography, discovering the Philippine Islands. They found there anarchy and despotism and they established order and justice. They found slavery and they destroyed it, thus granting everybody political equality. They ruled the inhabitants with laws, benevolent laws. They christianized them, civilized them, defended them from the Chinese, the Moro pirates, and the European invaders. They spent on them much gold and then set them free."

Photographic Division, C. A.

Old Spanish hospital, Los Baños; now housing offices of the economic garden, Bureau of Plant Industry, and elementary classrooms, Bureau of Education.

THE ABACÁ-DISEASE SITUATION IN DAVAO [1]

G. O. OCFEMIA
Of the Department of Plant Pathology

WITH TWO TEXT FIGURES

The first report from Davao of the occurrence on abacá of a disease similar to, if not identical with, the banana wilt came on February 20, 1937, from Mr. F. G. Roth of the Columbian Rope Company. In his letter on March 30, 1937, Mr. Roth described the so-called new disease and invited the writer to visit Davao in order to see the destructiveness of the disease.

On April 20, 1937, Mr. H. T. Edwards, specialist in fiber plant production of the United States Department of Agriculture, came to the College of Agriculture at Los Baños and requested the writer to visit Davao and look into the abacá-disease situation in that province.

A trip to Davao was made possible by the President of the University of the Philippines and the Dean of the College of Agriculture, who kindly granted the writer permission to go and made funds available for the trip.

The writer left Los Baños on April 28, and returned on May 17, 1937, a period of 20 days. Ten days were spent in Davao and neighboring localities, and the other ten days were spent traveling in steamers.

DISEASES OF ABACÁ IN DAVAO

Bunchy-top

According to Mr. U. Kojima of the Ohta Development Company, bunchy-top of abacá was first noted in Davao about the middle part of 1931. The disease was first discovered at Libby (The Talomo Plantation Co.) and Tugbok, Guianga. It was also found in several other places almost at the same time. The disease is present at low and at high altitudes. All varieties of abacá planted in Davao, that is, Tañgoñgon, Maguindanao, Buñgulanon, and Lauan, are attacked with the same degree of severity.

In going through the abacá plantations in Eden, Ohta Development Company, Biao School Place, Mampising Agricultural High School, Pendisaan Plantation, Inc., at Pendasan, Pantukan, and Min-

[1] Experiment Station contribution No. 1178. Received for publication, June 6, 1937.

danao Reclamation Company at Tunkalan, the writer noted that bunchy-top is an important disease of abacá in Davao. Some people, however, cannot recognize bunchy-top because of the variation of symptoms due to climate, soil, and varietal characteristics of abacá.

The presence of chlorotic streaks, transparent veins, and parchment-like areas on the youngest furled leaves of abacá is the most

Fig. 1.—A stool of abacá infected with bunchy-top showing that the older stalks may not exhibit the characteristic symptoms of the disease. The older stalks that do not show the transparent streaks and parchment-like areas may even flower. Photograph by the Photographic Division, College of Agriculture, March 9, 1937.

reliable symptom of primary infection. There are cases of bunchy-top infection, however, in which the leaves of the suckers exhibit only the curling of the blades upwards along the margins without other markings on the leaf blades. This symptom is often seen on suckers of infected stools in Davao. The older plants of a stool do not ex-

hibit either the open rosette arrangement of the leaves or the characteristic markings on the blades (Fig. 1). In many instances infected abacá plants in Davao have only a few leaves, and these are borne at about the same level at the upper end of the stalks. The leaf blades may be dead, dry, and light or dark brown. The petioles and midribs are greenish straw in color, straight and almost vertical in position. The appearance of the plants in advanced stages of infection is similar to that shown in Plate IB of an earlier paper by the writer [2].

Specimens of bunchy-top of abacá were collected for the writer by Mr. Kojima, from Tamayong, at an altitude of 500 meters.

Mosaic-like disease

In some places in Davao the bunchy-top situation is aggravated by a second virus-like disease. The symptoms of this disease resemble those of mosaic on account of the mottling of the leaves, petioles, and upper portions of the leaf sheaths.

On May 12, 1937, the writer collected several plants of *Canna indica* at Bankas, on the way to the Mindanao Reclamation Company plantation at Tunkalan. On account of the resemblance of the mottling on the leaves of this *Canna* to that of abacá, the specimens were brought to Los Baños for a more careful study. Transmission studies by Mr. Martin S. Celino and the writer are now under way to determine the relation of the abacá-mosaic-like disease to *Canna* mottling, the methods of transmission of the two diseases, their host ranges, etc.

The specimens of the mosaic-like disease of abacá were collected for the writer also by Mr. Kojima, from Wañgan, at an altitude of 300 meters.

Banana-wilt-like disease

The third, or new, disease that is causing no little alarm in Davao, and is compelling plantation owners to cut down hectare after hectare of their abacá, seems to be not a single trouble. At present, the new disease is destructive only at high elevations. As the third disease is recognized by reddish violet color in the vascular vessels of the false stems and corms of abacá (Fig. 2), there seems to be very little doubt that this is the banana wilt. Until the fungus on the abacá is definitely identified with *Fusarium oxysporum* Schlt. f.

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[2] OCFEMIA, G. O. 1930. Bunchy-top of abacá, or Manila hemp: I. A study of the cause of the disease and its method of transmission. American Journal of Botany 17: 1–18. *Pl. 1–4.*

3 Wr., the third abacá disease will be referred to, in this paper, as "banana-wilt-like disease."

On banana the presence of reddish violet color in the vascular vessels is the most reliable symptom of wilt disease caused by the fungus *Fusarium oxysporum* Schlt. f. 3 Wr. This fungus brings about wilting and eventually kills the banana by the toxic substance that it produces within the host.

The banana-wilt fungus is widely distributed in the soil of tropical countries. Reinking (1934)[3] lists the countries in which banana wilt occurs. In the Philippines, wilt disease attacks only the Latundan banana. Lacatan, Saba, Gloria, and Buñgulan are not attacked by the disease.

Our first knowledge that abacá is attacked by banana wilt came from Mr. Edwards. When he visited the College of Agriculture on March 30, 1927, he informed the writer that the abacá plants from the Philippines which were introduced into Central America are affected by a disease similar to the banana wilt. Dr. Otto A. Reinking, at that time pathologist to the United Fruit Company, Boston, Massachusetts, in his letter of July 23, 1927, stated that the disease on abacá in Central America is without doubt the banana wilt. Doctor Reinking, however, stated that cultural studies are necessary before the disease can be stated definitely. According to Doctor Reinking, the variety affected by the banana wilt in Central America is the Buñgulanon from Davao (Leoncio, 1930, p. 27).[4]

In a letter dated November 27, 1929, Mr. J. H. Permar, at that time with the Research Department of the United Fruit Company, Panama Division, Almirante, R. P., stated that his brief experience leads him to believe that all the abacá varieties growing in Panama are to some degree susceptible to the wilt disease. Mr. Permar added that Buñgulanon, as reported by Mr. Edwards and Doctor Reinking, is so far the most susceptible. Mr. Permar further stated that plantings from portions of rhizomes from old mats are most susceptible to banana wilt during the first six to twelve months of growth. Later, however, the affected mats improve so that at maturity scarcely any symptom of the disease may be noted (Leoncio, 1930, p. 40). It may thus be seen that the occurrence of the banana-wilt-like disease

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[3] REINKING, OTTO A. 1934. The distribution of banana wilt. Philippine Journal of Science 53: 229–243. *Pl. 1–5.*

[4] LEONCIO, JACINTO B. 1930. The relation to abacá, or Manila hemp of the banana-wilt fungus Fusarium cubense EFS. The Philippine Agriculturist 19: 27–42. *Fig. 1–2.*

on abacá is not new to us. The new aspect of the disease seems to be its association with the stem borer at high altitudes.

Specimens of the banana-wilt-like disease on abacá were collected by Mr. A. Nagaya, manager of the Pendisaan Plantation, Inc., Mr. Ureta, and the writer. The specimens were obtained from young replants of abacá (Fig. 2) in the Pendisaan Plantation, Inc., at Pantukan, on May 8, 1937. The replants used in this plantation are large corms, the top and bottom of which have been cut off. Some of the corms were halved while others were not cut. The Pendisaan Plantation, Inc., is only a few meters above sea level. The disease was not serious at this elevation and it was not noted on older abacá plants in this plantation.

Fig. 2.—Three young abacá replants collected from the Pendisaan Plantation, Inc., Pendasan, Pantukan, Davao, showing part of the mother corm. The plant to the left is free from the reddish violet vascular symptom in the corm. Arrow on plant in center points to a slight infection. The plant to the right shows an abundance of the reddish violet streaks of vascular vessels in the corm. About 1/2 ×. Photograph by the Photographic Division, College of Agriculture, June 3, 1937.

On May 12, 1937, the banana-wilt-like disease was noted in abundance on older plants in the plantation of Mindanao Reclamation Company in Tunkalan. This plantation is at an elevation of about 500 meters (1700 ft.). At this elevation the abacá-stem wee-

vil, *Odoiporus* sp.,[5] is a destructive pest of abacá. The specimens examined for symptoms of the "so-called new disease of abacá" in Davao have tunnels of the stem weevil in the pseudostems and corms.

In the third, or so-called new, disease of abacá in Davao, infection seems to take place in the corm or at the base of the false stem. Entrance of the causal organism is effected through openings in the corms or roots made by borers or by any other means. On the outer leaf sheaths, a discoloration and rotting start from the opening made by the borer. In the course of a few days, oval or oblong areas of rotting tissues, which enlarge gradually, may be readily distinguished. The long diameter of these areas is parellel with the long axis of the false stem of abacá. Within the false stem, reddish brown areas which run up and down the stem may be noted. These areas finally rot and give off an acrid odor. The odor is due perhaps to rotting excreta of the borer in the tunnels. Several insect tunnels may be found in one plant. The disease causes rotting of the outer sheaths before the inner tissues are involved.

To the writer the third, or so-called new, disease of abacá in Davao is not a single trouble. It seems to be the combined effect of the stem weevil and of the banana-wilt-like disease on abacá plants which have been weakened and rendered susceptible by growth at high elevation, and by other factors not well understood.

Although there seems very little doubt that one of the factors in the third abacá disease in Davao is the banana wilt, cultural studies by Mr. Celino and the writer are under way to determine definitely the relation of the fungus to *Fusarium oxysporum* Schlt. f. 3 Wr.

WHAT SHOULD BE DONE TO CONTROL THESE DISEASES

Bunchy-top

The measures recommended by the writer for bunchy-top are described in detail in College of Agriculture Experiment Station Circular No. 27, issued August, 1934, entitled "Bunchy-top of abacá." These measures are known by the plantation owners in Davao and, through the kind cooperation of Mr. Kojima, they are applying them in their abacá fields.

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[5] UICHANCO, L. B., The Philippine Agriculturist 25 (1936) 576, reports the identity of this weevil as *Odoiporus longicollis* (Olivier). Further studies, however, and a detailed comparison with specimens of *O. longicollis* from Java, which he received subsequently, have convinced this author that he is dealing with a different form—apparently a new species of *Odoiporus*.

Mosaic-like disease

If this disease is proved to be a true mosaic, the important modification to the measures against bunchy-top is the disinfection of tools used for eradicating infected plants before these tools are used on healthy plants. This precaution is necessary because, as a rule, the infective material of mosaics is more virulent than that of bunchy-top. For this reason the disease may be readily transmitted by mechanical means.

Banana-wilt-like disease

As the disease is similar to, if not identical with, the banana wilt, its cause is widely distributed in the Philippines and in other tropical countries. At low elevations in Davao the disease seems to be but a minor nuisance to abacá at present. At high elevations, however, its effects are more ruinous because of the weakening effects of stem-weevil infestation, unfavorable altitude, and perhaps varietal susceptibility and other factors not well understood.

The most practical solution for the banana-wilt-like disease at high elevations and other places where the disease is severe is to destroy the abacá completely. The land should then be planted to crops recommended for Davao conditions by the Bago Experimental Station. This is the only practical measure because the fungus is widely distributed, and it cannot be destroyed in the soil.

FURTHER WORK NEEDED IN DAVAO

If a man of the training and experience of Mr. Martin S. Celino, assistant in plant pathology, can be detailed in Davao at the expense of the University of the Philippines or of abacá planters to carry out the work under the writer's direction, many of the questions connected with abacá diseases in that region may perhaps be clarified.

SUMMARY

1. The abacá diseases in Davao are bunchy-top, mosaic-like disease, and the so-called new disease. Bunchy-top is important and in some places it is aggravated by the mosaic-like disease.

2. The so-called new disease is not a single trouble. It seems to be the result of the combined effects of banana-wilt-like disease and the stem weevil, *Odoiporus* sp., on plants weakened by high altitudes and perhaps varietal susceptibility and other factors not well understood. Although present at low and at high altitudes, the banana-wilt-like disease is at present destructive only at high elevations.

3. The control measures for bunchy-top, mosaic-like disease, and banana-wilt-like disease are described briefly.

4. Work on the mosaic-like disease and on the banana-wilt-like disease of abacá is now under way in the College of Agriculture at Los Baños.

ACKNOWLEDGMENTS

I take pleasure in acknowledging my indebtedness to the President of the University of the Philippines and to the Dean of the College of Agriculture for granting me their permission to make the trip to Davao and for making funds available for the trip. I wish to thank Mr. H. T. Edwards, specialist in fiber plant production of the United States Department of Agriculture, for requesting me to make the trip. Thanks are due Mr. U. Kojima, of the Ohta Development Company, for many courtesies and for specimens of bunchy-top and mosaic-like disease. I am indebted to Mr. Samuel S. Fraser, manager of the Columbian Rope Company, for furnishing me with copies of memoranda on the so-called new abacá disease, prepared by Mr. F. G. Roth; and to Mr. A. Nagaya, manager of Pendisaan Plantation, Inc., for specimens of the red vascular disease of abacá. Finally, I wish to express my gratitude to Mr. Eligio C. Ureta, principal of the Mampising Agricultural High School, for much assistance in gathering information and for accompanying me to Japanese plantation managers.

A BIOMETRICAL STUDY OF THE ADULT COMPONENTS OF PHILIPPINE LOCUST SWARMS [1]

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WITH TEN CHARTS

Since Uvarov (1921) published in a preliminary form his theory of phases in connection with *Locusta migratoria* Linnaeus, our conception of locust biology has taken a new aspect. An important working hypothesis has become available for a more rational solution of the locust problem. Uvarov's theory of phases consists essentially in the recognition of four more or less distinct, but genetically related, phases; namely, solitaria, transiens (congregans), gregaria, and transiens (dissocians). Ordinarily, locusts occur in the solitary, or non-migratory, phase. As a response to certain unusual conditions of the environment, such as drought, etc., the solitary locusts give rise in the succeeding broods to the transiens (congregans) phase, which in turn produces in subsequent broods the gregarious phase. Upon return of more normal conditions, the offspring of the gregarious phase develops into the transiens (dissocians) phase, preparatory to reappearance, in the next succeeding generations, of the solitary. The migratory locust is, therefore, a biological race of the solitary, or non-migratory.

Experimental evidence in support of this theory soon began to accumulate, chiefly through the careful work of Faure (1923 and later papers), Uvarov himself, and a number of other workers in various parts of the world. These investigators have established beyond question the essential validity of the phase theory, and they have, moreover, shown that it is equally applicable to other locust species that exhibit a swarming habit.

Review of literature

A discussion of the identity of the migratory locust in the Philippines as *Locusta migratoria* Linnaeus subspecies *manilensis* (Me-

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[1] Experiment Station contribution No. 1179. The data used in the present article were taken in part from thesis No. 1080, presented by the junior author for graduation, 1937, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture. The senior author assumes full responsibility for all errors in the discussion and interpretation.

yen), together with the geographical distribution of the subspecies, is given by Uvarov (1936). Uichanco (1936a) brings together all available data on the occurrence of locust swarms in the Philippines since 1569 and makes an attempt to correlate these phenomena with sunspot and climatic cycles. A great deal of the older literature on the Oriental migratory locust deals with reports on the existence of swarms, the damage they cause, control measures, and, in comparatively more recent times, studies of life history and parasitism. Outside of the measurements of morphological parts given in Uvarov's (1936) paper, no detailed work has so far been undertaken in the Philippines on this subspecies making direct use of the theory of phases, except an incidental discussion in a paper by Gonzales (1932) and another preliminary report by Otanes (1932). Otanes' paper is, of course, a progress summary of an extensive series of field and cage observations which he and his co-workers in the Bureau of Plant Industry have been conducting for a number of years on the biology of the migratory locust.

Objects of the present work

The work was planned to include three objects: (*a*) to find out the extent and manner by which Uvarov's theory is applicable to *Locusta migratoria manilensis* under Philippine conditions; (*b*) to determine the composition of adult swarms in different Philippine localities at different times; and (*c*), if possible, to utilize the data thus obtained in judging such relationships as might exist in the occurrence of swarms on the various islands.

Time and place of the present work

The work was started in August, 1934, and concluded in February, 1937. Owing to numerous interruptions, as well as the labor involved in detailed measurements of various parts of each specimen and the time consumed in calculation and tabulation of thousands of data, the work dragged on for about two and one-half years. All the measurements and calculations were conducted in the laboratory of the Department of Entomology.

MATERIALS AND METHODS

The material consisted of forty-nine lots, totalling 19,619 specimens (10,385 females and 9,234 males), collected in southern, southeastern and northern Luzon (the Bicol Peninsula, southern Tayabas, Batangas, and Cagayan provinces), Samar, Leyte, Masbate, Burias Island, Panay, Cebu, and Mindanao (Zamboanga, Cotabato, Agusan,

Surigao, Bukidnon, Oriental Misamis, and Davao provinces) in 1932, 1933, 1934, 1935, and 1936. The 1932 lots, all from Negros, and that part of the 1933 material which came from the same island were secured chiefly through the interest and coöperation of Mr. Fausto E. Villanueva and Mr. Getulio B. Viado, while they were working as assistant entomologists in the research bureau of the Philippine Sugar Association. The rest, which constitute the greater bulk of the material, was sent to us at our request by field men of the Bureau of Plant Industry, through the good offices of its former director, Dr. Manuel L. Roxas, and of Dr. Gonzalo Merino and Mr Faustino Q. Otanes, chief and assistant chief, respectively, of the plant pest and disease control division. Data on dates, localities, number of included specimens, and sex-ratios in the various lots are given in table 1.

All measurements were made with the aid of a pair of dividers and a rule, calibrated to 0.5 millimeter. At the time the work was begun, the most complete paper available to us dealing with measurements of locust parts for biometrical purposes was that of Zolotarevsky (1933); so we decided to adopt in part his method of treatment. Uvarov's (1936) paper used an extra criterion, the width of pronotum at constriction and the ratio thereof with length of pronotum. Unfortunately, this suggestion came too late for us to take advantage of it, since it would have meant redetermining in addition all the other characters in each of the 19,619 locusts. By following Zolotarevsky's method, the following data were secured:

(1) Width of the head (T) measured along the greatest breadth at genae
(2) Breadth of pronotum at shoulders (M)
(3) Length of pronotum along median carina (P)
(4) Height of pronotum at point of constriction (H)
(5) Length of femur (F)
(6) Length of tegmen (A)
(7) Width of tegmen (B)

The following ratios were taken: A/B, A/F, P/T, M/T, H/T, and H/P.

Calculations of the mean, standard deviation, and coefficient of variation were made according to accepted statistical methods.

RESULTS AND DISCUSSION

Degree of susceptibility of sources of our research material to locust outbreaks

A tentative evaluation of various Philippine localities as regards degree of propensity for locust invasion has been given in three earlier publications (Uichanco, 1936a, 1936b, 1937). Although the

details of our supporting data for the grouping of localities with respect to locust susceptibility, on p. 339 of the first article, are still awaiting publication, we feel justified in adopting it as a guide in making our classification in the present paper (table 1), largely because experience in the past and in recent locust outbreaks has been accordant in the main with the arrangement. For facility in computation, the places from which material was secured were grouped under "susceptible localities" when they lie in Mindanao and eastern Visayas, through and including the Bicol Peninsula, except that localities such as Zamboanga and Samar are relegated to the "non-susceptible" group. Likewise, relatively "non-susceptible" sources of material are made in the distribution of the present lots to comprise, in addition to Zamboanga and Samar, Cagayan de Luzon, Batangas, and Tayabas.

Relation of collection dates to the present locust cycle

The present locust cycle apparently had its inception around 1930 (Otanes, 1932; Uichanco, 1936a) and it probably reached its highest peak in 1935. In the years when the specimens were collected for the present paper, namely, 1932, 1933, 1934, 1935, and 1936, the infestation remained at a high level (see Uichanco, 1936a, chart 2), so that the forces at work in bringing about swarm production, together with such pleomorphic responses as the components in the locust population might exhibit, could probably be observed at their most active points.

It must be remembered in this connection that even around the peak of an outbreak cycle, a definite seasonal fluctuation does exist. Generally the seasonal curve of infestation during a locust year in the Philippines abruptly rises soon after the beginning of the rains, and either proceeds further on its upward course or remains at a stationary high level during the ensuing three months. The severity and extent of the outbreaks then relent in the latter part of the rainy season, and the low level is maintained throughout the entire dry season. Hence, in the grouping herein adopted for a comparative study of the seasonal trends of swarms, June, July, and August are considered "months of high infestation", and the remaining months of the year, "months of low infestation."

Reasons for selection and treatment of the adult morphological parts studied

Uvarov and other workers have demonstrated that the transition from the non-migratory phase to the migratory in locusts becomes manifest, not only biologically, such as in change of habit from soli-

tary to gregarious, but also in the altered character of certain morphological parts. For instance, the pronotal keel, which in *Locusta migratoria* Linnaeus is somewhat pronounced and nearly straight in the solitary form, becomes more or less obsolescent in the migratory, and is, moreover, bent with the constriction that marks the pronotum in the latter. Likewise, the pronotum in the gregarious phase is rela-

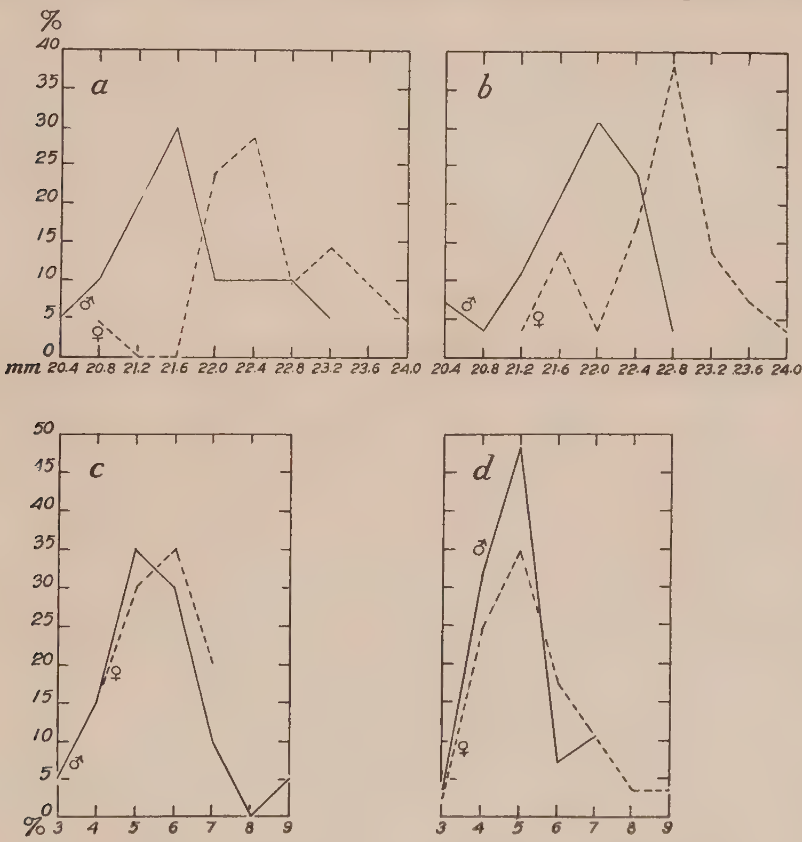

Chart 1.—Per cent distribution of the various lots in terms of F (length of femur). (*a*) Mean of absolute length in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

tively shorter in proportion to its breadth and the ratio between the hind femur and the tegmen is greater. The idea in the present investigation has been to take advantage of these known facts and, through statistical approach, make an effort to solve some of our questions relative to locust swarms.

In table 8, a comparison is made of some of the dimensions and their ratios given by Uvarov (1936) and the corresponding data from the present work. Although some discrepancies may be noted in the means of the absolute dimensions for A and F, the two sets of figures show a remarkably close agreement for the ratios A/F, P/T, and H/T in both sexes.

Correlation of morphological pairs

It is, of course, obvious even without statistical analysis that the dimensions of morphological characters in adult locusts should be more or less positively correlated because the parts would naturally correspond proportionately to the total body-size of the individual. The coefficients of correlation (table 2) were determined, however, mainly as a guide in judging the suitability of the various parts studied and their ratios as criteria in the present work. A (length of tegmen) and B (width) show the lowest correlation coefficients for the male and also quite a low coefficient for the female; H (height of pronotum) and T (width of head), the highest for both sexes. Theoretically, the smaller the coefficient of correlation of the paired criteria, the more suitable they should be for use in a ratio because then such characteristic morphological divergences as the locust population may pass through in changing from one phase to another would show more pronounced contrasts. This apparently is not the case, however, since it will be seen (table 3) that the ratio A/B, compared with the ratios of other pairs, exhibits the smallest coefficient of variation. At any rate, in none of the pairs listed in table 2 is the coefficient of correlation so high as to preclude the occurrence of detectable quantities of significant differences.

An interesting point is brought out by these coefficients of correlation; in certain pairs of characters they are higher in the male than in the female, and in others, higher in the female than in the male. This curious discrepancy has been noted in some of our other results (tables 4, 5, 6, and 7; charts 1 to 9) and it is probably indicative of a difference in the degree of morphological readjustment in the two sexes in relation to the phases.

Composition of the swarm according to locality

In tables 4 and 7, a comparison is given of the composition of swarms in "susceptible" and in "non-susceptible" localities with the lots grouped as described earlier in the present discussion. In the analysis, the individual locusts were taken as the units for computation of the required statistical constants for the "susceptible" and

for the "non-susceptible" groups, and the separate component lots disregarded. The criteria used were A (length of tegmen), B (width of tegmen), F (length of hind femur), and the ratios A/B and A/F. The two groups of localities showed no significant difference, except

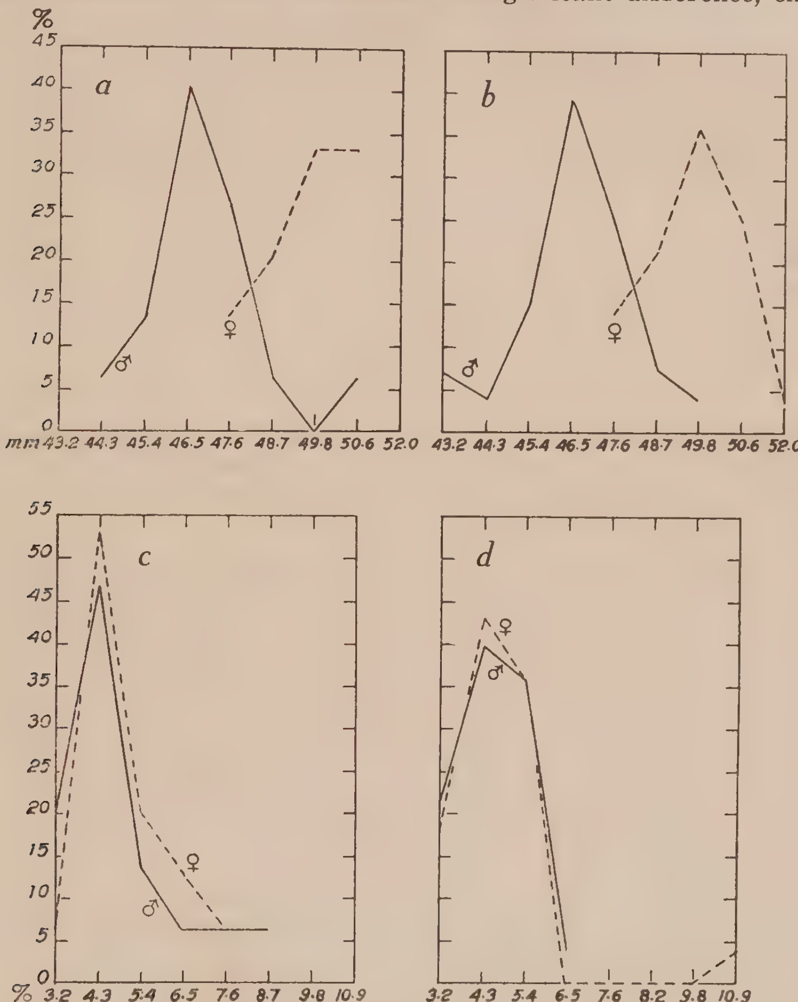

Chart 2.—Per cent distribution of the various lots in terms of A (length of tegmen). (*a*) Mean of absolute length in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

in a relatively trifling way, in the coefficient of variation of the width of tegmen (B) in the male. A probable interpretation of this finding is that, on occasions when a locust outbreak occurs, environ-

mental conditions in a "non-susceptible" Philippine area are essentially similar to those in a "susceptible" in so far as swarm production and maintenance are concerned. Of course, another factor is that interisland migration which, as is well known, frequently happens, serves to homogenize the composition of adult swarms over the Archipelago. The sex-ratios (table 1), however, in lot 48 from Iligan Point, Cagayan, Luzon (0.48), in lot 45 from Taal Island, Batangas (0.43), in lot 49 from Catbalogan, Samar (0.44), in lot 36 from Pagbilao, Tayabas (0.39), in lot 41 from Salcedo, Samar (0.37), which are relatively non-susceptible localities, would serve to introduce an element of weakness in adducing interisland migration as the sole explanation. These sex-ratios are rather low, and, as may be inferred from a discussion on this subject elsewhere in the present paper, the lots were probably collected from swarms that were young enough to have developed locally, rather than from immigrating fliers from a distant source. Moreover, one or more broods of the gregarious phase have been observed to develop in nearly every district in the Philippines at one time or another during bad locust years.

The question naturally arises, in view of the foregoing considerations, as to whether we can consistently insist that any group of Philippine localities may be regarded as relatively non-susceptible to locust outbreaks. Our results certainly cannot justifiably be taken as evidence against that premise, inasmuch as the present data are based on material collected under swarm conditions around the high peak of an outbreak cycle. At those times, suitable breeding areas presumably become temporarily extended, but in such incidental places the swarm population can apparently gain only a precarious foothold. A discussion of the probable permanent reservations of the migratory locust in the Philippines is given by Uichanco (1936a, 1936b, 1937) and also in a forthcoming paper. Pertinent to this topic, we might relate our experience in rearing migratory locusts in cages at this college, which is situated in a place that we consider among the relatively non-susceptible localities. We started the work when locust swarms invaded the campus in 1922. We succeeded in raising a few broods up to 1924 after which the breeding stock rapidly deteriorated; the adults had crumpled wings and in other respects looked unpromising. This resulted, despite the fact that plenty of space was allowed in the cages, the soil was changed with rea-

sonable frequency, and fresh grass supplied regularly. The project finally had to be abandoned.

On June 21, 1934, one adult female was collected by Mr. G. B. Viado from the Los Baños economic garden of the Bureau of Plant Industry. At no time from 1922-23 to the present has there been a swarm invasion in the immediate vicinity of this town, although the locust may well have been a straggler from swarms originating

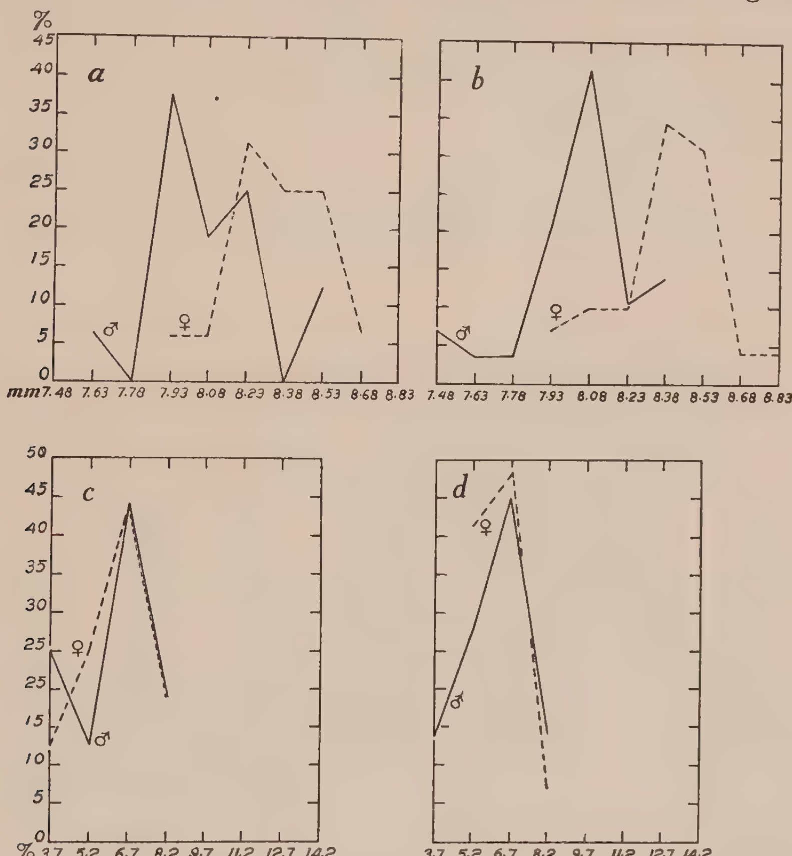

Chart 3.—Per cent distribution of the various lots in terms of B (width of tegmen). (*a*) Mean of absolute width in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

in the Bicol and Bondoc Peninsulas. This lone specimen, which must have been previously fertilized in the field, was induced to lay eggs in a cage in our insectary. The result was a succession of healthy broods. Adults from this culture were identified by Doctor Uvarov,

to whom we sent specimens, as *Locusta migratoria manilensis*, transient phase, the change in form, presumably from the solitary, being, according to him, probably the result of close confinement. Vigorous locusts continued to appear in our rearing cage until about September, 1936. Then we detected untoward symptoms, not unlike those that appeared in 1923-24. Upon examination, the insects were found to be heavily parasitized by mites at the bases of the tegmina and wings and on other thinly chitinized portions of the body. In February, 1937, the cage contained but a few languid adults, whose dejected forms cast the gloomy shadow of a decadent family line. By April, 1937, all the locusts were dead. These are isolated cases, it is true; but they probably give a good picture of the sequence of events in a relatively non-susceptible Philippine locality upon withdrawal of the fortuitous set of conditions which temporarily allow outbreaks.

Seasonal trends of the swarm components

The morphological parts and their ratios studied in this part of the work are the same as those used in the preceding discussion. The dimensions, with the individual again as the unit, in the lots collected from June to August are grouped under "months of high infestation", and those from September to May, under "months of low infestation." No distinction as to locality is made, in view of our conclusion that there is no significant difference in either the absolute or the relative dimensions of the morphological parts considered when the locusts are compared in terms of their sources. Tables 5 and 6 give the results, wherein it will be seen that a significant difference exists in the coefficient of variation of the ratio of length of hind femur to length of tegmen (A/F), which is higher in months of high infestation than in months of low, and the difference between the two groups markedly greater in the female than in the male. This difference in the degree of variability of A/F in the two seasons is probably due to changes occurring in the length of hind femur (F) rather than to those in the length of tegmen (A), which, like its width (B), shows no significant difference for the two sets of months, either in its mean or in its variability. The greater constancy of the male, in contrast with the more fickle nature of the female, is further emphasized by the difference of the coefficient of variation of A/B, which is high and significant for the female, and very small and inconsequential for the male.

As a supplement to the foregoing treatment, the distribution of the means and of the coefficients of variation of the dimensions of various parts and their ratios were plotted on charts 1 to 9. The mean of each lot is used herein as the unit in order to get an idea of mass, instead of individual, trends. It is believed that, even with

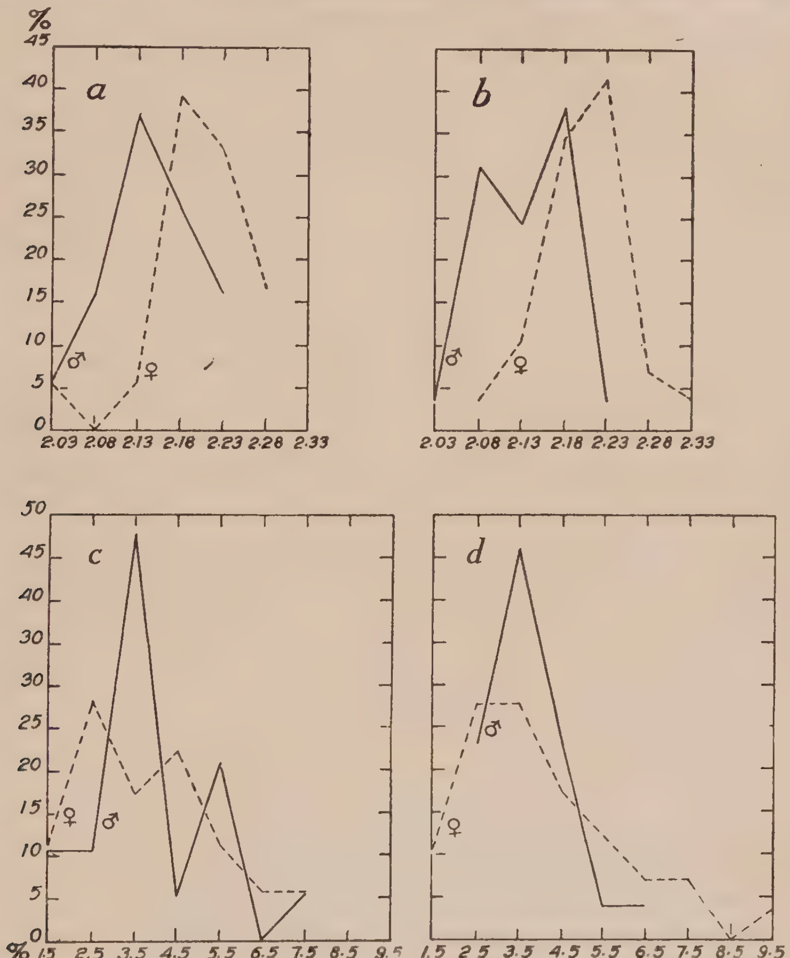

Chart 4.—Per cent distibution of the various lots in terms of A/F (ratio of length of tegmen to length of femur). (*a*) Mean of ratio in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

this method of approach, individual trends will be adequately accounted for by the nature of distribution of the coefficients of variation of the various lots. In addition to A, B, F, and A/F, H (height

of pronotum at constriction), P (length of pronotum along median carina), T (width of head), H/P, and H/T are also used. These other characters are added, because H and T, it will be recalled, show the highest correlation, and we thought that, for one thing, we might help clarify certain points brought out in our earlier discussion. H, P, and H/P are, likewise, used because of the established relationship of these parts which varies with the change of phases. Because only twenty lots can be included in the group for the months of high infestation, as against twenty-nine for the months of low, their numerical distribution is reduced to a percentage basis, to permit a direct comparison of data.

As has been expected, somewhat greater contrasts are shown by F (chart 1) than by A (chart 2). F has about the same mode for each sex, but it is somewhat higher in the months of low for the female in the distribution of the mean and for the male in that of the coefficient of variation. The biggest difference is noticeable in the distribution of coefficients of variation, which is about equal for A in both groups of months. In F, on the other hand, a considerably greater dispersal occurs for the months of high infestation than for the months of low. The absolute dimension and variability trend of B (chart 3) are essentially similar to that of A.

A/F (chart 4) shows no difference that can be collated with the findings in statistical analysis, except that in the distribution of the coefficient of variation, the two sexes show a discrepant behavior. This lack of harmony has been explained above as possibly the result of difference of morphological responses of the two sexes to change of phases.

T (chart 6) shows greater dispersal in the male for both the mean and the coefficient of variation in the months of low infestation than in the months of high, while H (chart 5) shows a difference in the markedly reduced trend of variability in the male only during the months of low. The ratio H/T (chart 7) for both sexes tends to crowd around the mode in the months of high to a more pronounced degree than in months of low. This crowding is more greatly accentuated in the distribution of the coefficient of variation for the female. Such contrasting behavior of H, T, and H/T would probably make these characters suitable as criteria for investigational work on trend of swarm composition, despite their high coefficient of correlation.

P (chart 8) shows but little difference in the trend of the curves in both sexes for either set of months. In the distribution of the

coefficients of variation of this character, however, the female curve during the months of high falls far below that of the male, although a wider dispersal of variation of this character is exhibited in the male. The ratio H/P (chart 9) shows very little difference.

It may be pertinent to introduce at this point an explanation as to why we did not avail ourselves also of the figures obtained for

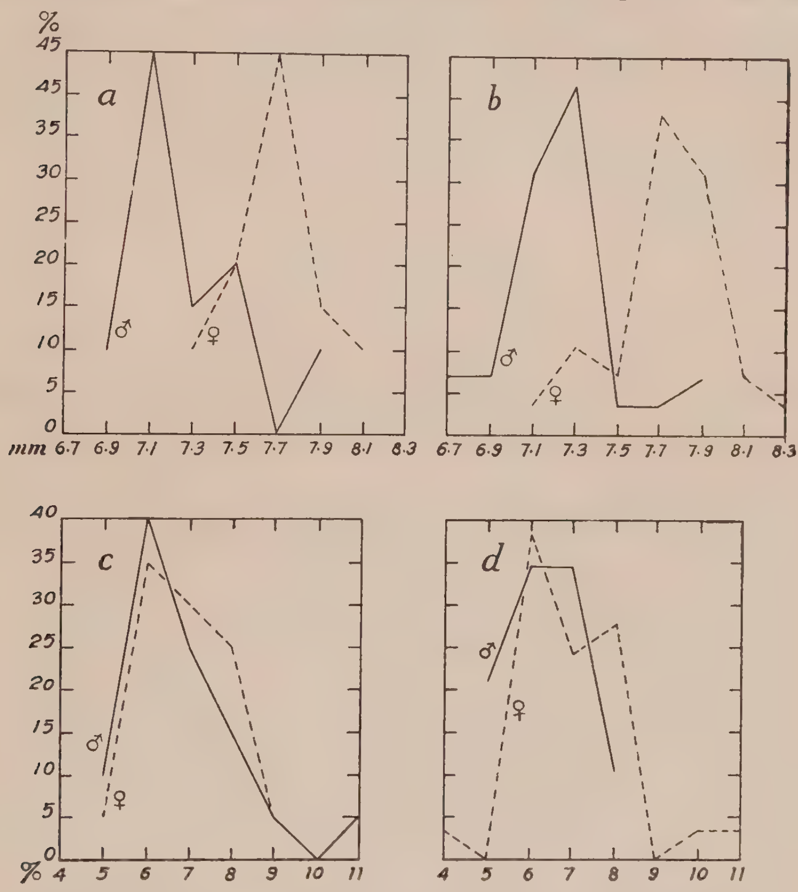

Chart 5.—Per cent distribution of the various lots in terms of H (height of pronotum at point of constriction). (*a*) Mean of absolute height in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

M, M/T, and P/T. The resulting ratios are but a little more than 1 for P/T and less than 1 for the others. Although H/P is open to the same objection, its use was considered more justifiable on the grounds stated above. The differences are frequently matters of

only a couple of hundredths or so of a per cent. Such small quantities do not lend themselves as readily to calculation and interpretation as do the higher figures obtained in the characters we adopted more generally as criteria. Moreover, considerable error must have crept into the measurements of such parts as breadth of shoulder, length of pronotum, and width of head. These parts could not be laid flat on the surface of the table, and thus the manipulation of the dividers was rendered more difficult and less exact. One fact is patent, however, and that is that the characters we decided upon as the most suitable in the present work show sufficient consistent differences or similarities under given sets of conditions to make them acceptable as criteria.

Probable relation of the present findings with conditions obtaining in the field

When swarms occur, it is of course reasonable to expect that they will consist largely of the gregarious phase, plus a probable admixture of the transient phase of either the dissocians or the congregans type. These two kinds of intermediate forms are apparently indistinguishable morphologically. Theoretically, the appearance of transiens (congregans) should reach its highest point when the swarms are produced most actively at or near the beginning of the months of high infestation, toward the conclusion of which season, transiens (dissocians) should supervene. An examination, however, of the means and coefficients of variation of the various characters we used, as given for each lot in tables 9 to 22, and a comparison of these with the trends in their corresponding charts, lead to a more qualified conclusion. For convenience, pertinent data, together with those in table 1, were reclassified according to seasonal distribution of the coefficients of variation of A/F, in table 23. Greater or smaller coefficients of variation for A/F are as likely to occur during months of high as during months of low infestation. Likewise, the much higher aggregate coefficient of variation for this ratio in months of high infestation, wherein the trends of distribution of this statistical constant in the included lots follows about the same course as in the months of low infestation, would seem to indicate that even from June to August sizable proportions of both types of the transient phase must be produced. If this were not so, the rapidity with which swarms form presumably from transiens (congregans) in the months of high would soon bring about a temporary equilibrium and result in a good number of the lots studied of that group with nearly

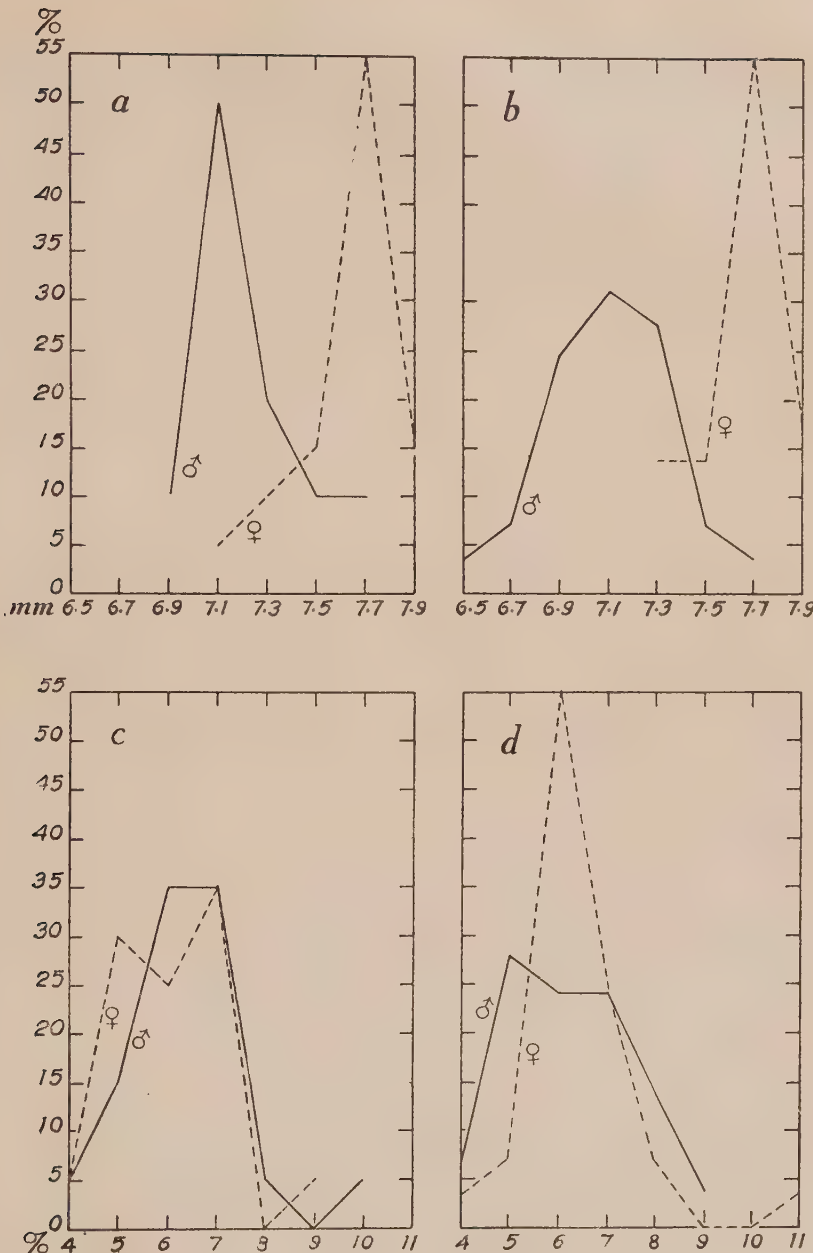

Chart 6.—Per cent distribution of the various lots in terms of T (width of head). (*a*) Mean of absolute width in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

pure migratory-phase components. The gregarious phase, according to Uvarov's (1928) conclusions, is constant in morphological characters in the adult stage. The consequent relative homogeneity in composition should have made the aggregate coefficient of variation for the months of high infestation very low—at least lower than in months of low, when conditions leading to the formation of swarms are presumably less stable.

The persistence to a greater or less extent of locust outbreaks in certain parts of the susceptible areas in the months of low infestation, as well as the markedly heterogenous composition of swarms in months of high, which apparently mean a frequent admixture of the transient phases with the gregarious, makes it seem unnecessary in the Philippines to invoke constantly a solitary phase of *Locusta migratoria manilensis* as the root of our locust troubles. Perhaps, in the light of the foregoing discussion, Uvarov's theory would require a somewhat modified restatement in the sense that the phases in question do not necessarily represent connected steps in a genetic cycle that proceeds in a single direction. With a clue from the known facts in other pleomorphic insect species, such as the termites, it might be equally as tenable to assume that the gonad of the female locust in any phase contains more than one type of ova, and on these the periodically recurring factors of the environment acting on the body of the mother exert a selective influence. In specifying the body of the mother as the subject of environmental influence, we are not unaware of the possibility of an error of omission of the egg and the nymphal stages. The fact, however, that hatchability of eggs in a pod is nearly 100 per cent and that the migratory nymphs exhibit the gregarious habit in the earliest nymphal instars would seem to preclude the postembryonic stages.

Uvarov (1928, p. 160) sums up the characteristics of the two extreme phases (forms) of *Locusta migratoria* as follows:

"The swarming phase, generally speaking, is characterized by the following principal features: eggs develop with a diapause; the hoppers are coloured reddish, orange, or yellow, with well-defined black markings, and are inclined to form bands and wander; the adults are constant in their morphological and colour characters (the latter, however, undergoing changes in connection with sexual maturation), form dense swarms, and do not develop the sexual products without a migratory flight, owing to an imaginal diapause.

"The solitary phase may be characterized as follows: The eggs can develop without a diapause; the hoppers are variable in colour, and, as a rule, this colour corresponds to that of their surroundings; they do not form bands and do not wander in masses; the adults are variable in their morphological and colour

characters (but do not change colour in connection with the maturation of the genital products), do not form swarms, and develop sexually without a diapause or a migratory flight.

"These diagnoses refer, of course, to the typical cases of the phases, but not to the intermediate forms, in which either one or other character or several of them may be less developed or lacking."

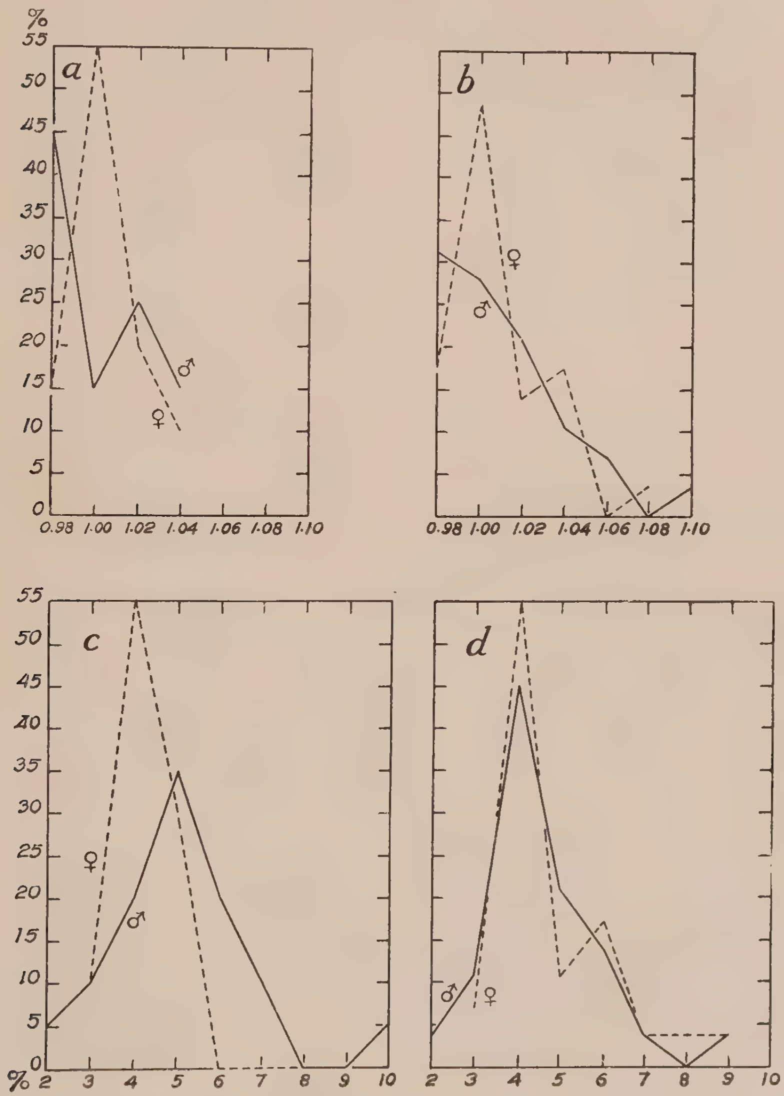

Chart 7.—Per cent distribution of the various lots in terms of H/T (ratio of height of pronotum at point of constriction to width of head). (*a*) Mean of ratio in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

Attention is especially called to the remarks on intermediate forms cited above, which would seem to suggest that there is no incompatibility in attributing to this type varying inclination toward the solitary phase, whose rôle it could conceivably assume without actually undergoing a change to that extreme.

From unpublished data on climatic relationships, a preliminary announcement of which appeared recently (Uichanco, 1937), the part of the Philippines which comprises the susceptible localities apparently follows a course which roughly describes a section of a parabola and extends from about the western part of the head of Davao Gulf, somewhere around the foot of Mount Apo, northward through Agusan, near the Bukidnon border, and thence through Leyte and the Bicol Peninsula. This parabolic line represents approximately the eastern limit of the susceptible area, and coincides with typical abacá districts (see Uichanco, 1936b). The greatest susceptibility to locust outbreaks is apparently exhibited by the Mindanao localities at the lowest end of the line, where the permanent reservation is presumably found. The intensity progressively diminishes along its northward course, and is relatively weakest in the Bicol Peninsula. Localities lying farther away from this line vary in their degree of susceptibility, although in no case probably is this equal to or greater than that of the Bicol Peninsula. In the highly susceptible areas, the extreme solitary phase probably has no chance to occur and, if we adhere strictly to the idea of a complete genetic cycle, this absence would cause a gap in a complete chain of phases that culminates in the gregarious. On the other hand, the modification suggested will, we believe, more adequately explain the outbreak or subsidence of swarms in the Philippines. This premise, moreover, would spare us from the disquieting civic indictments of a tenor similar to that by Uvarov (1936), to wit:

"* * * but an outstanding feature of local agriculture [in the Philippines] is the same system of shifting cultivation as described above for Borneo. According to Whitford, practically the entire land area of the Philippines was originally covered with unbroken forests. At present, however, about 40 per cent of the whole area is grasslands, while about 10 per cent is under cultivation. The grasslands, called locally cogonales, represent the product of shifting cultivation and of repeated burning of the grass. * * * The continuity of swarming during the last two decades sugests, however, that the system of shifting cultivation presents exceptionally favorable conditions for the production and maintenance of the swarming phase. Therefore, no definite hopes for the solution of the locust problem in the Philippines can be entertained until the ecology of cogonales in relation to locusts is studied in detail and a system of cultivation devised which would prevent a creation of artificial outbreak centers."

Incidentally, we might be permitted to point out that the grasslands of the Philippines, according to the latest figures of the Bureau of Forestry, cover an aggregate area of only 18.7 per cent,[2] and not 40 per cent.[3] This area is constantly being reduced, thanks

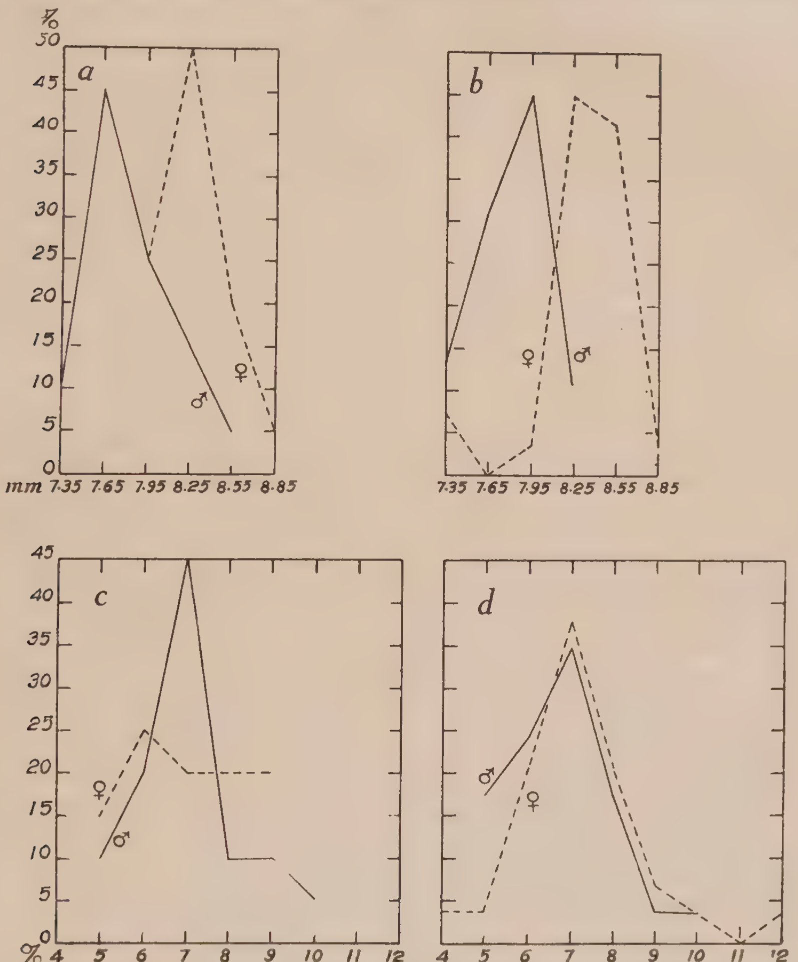

Chart 8.—Per cent distribution of the various lots in terms of P (length of pronotum along median carina). (*a*) Mean of absolute length in months of high infestation; (*b*) in months of low infestation (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

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[2] Data as of December 31, 1932, furnished through the courtesy of Director Florencio Tamesis, Bureau of Forestry.

[3] Whitford, H. N. 1910. The forests of the Philippines, vol. 1. The figures on land classification in this twenty-seven-year old publication are obsolete and unreliable. They are based on very rough estimates, with little supporting field data.

to the increasingly strict enforcement of the law prohibiting *kaiñgin* (shifting cultivation) since American occupation. At all events, the land covered by the grasslands cannot be made to shoulder the entire blame for the locust problem, for two main reasons: (1) As indicated in table 24, grasslands in Mindanao and Sulu, which include what is apparently our permanent locust reservation, represent only 18.49 per cent of the total grasslands for the entire archipelago. Likewise, the average proportion of grasslands in that district to the total land area in each province is only 11.50 per cent. Bukidnon, which is the most severely denuded province in Mindanao and Sulu, has only 44.81 per cent of its total area in grass and open lands. A large part of these is located at excessively high elevations and, hence, is presumably unsuitable for a protracted maintenance of locusts. The Luzon provinces, on the other hand, which we judge to be relatively non-suitable as locust reservations, include an aggregate of 45.26 per cent of all the grasslands in the Philippines. The grass and open lands average 34.68 per cent of the total land area of each province in this district. The most highly deforested provinces, namely Ifugao, Benguet and the city of Baguio, and Kalinga, have each from 60 to 69 per cent of the total provincial area in grass and open lands, nearly all again at high mountain altitudes. (2) Locusts have been a constant plague in the Philippines since before the arrival of Magellan, as may be judged from ancient legends, such as that of the Visayan goddess Lahon, cited by Uichanco (1936a). When the Spaniards came, the population of the Philippines was estimated at nearly 500,000, its greatest density being located at some distance from what we believe to be locust reservations and mostly along the coasts. Whatever shifting cultivation these early inhabitants could have practised must have been insignificant compared with that of the later centuries. By the close of the Spanish régime, the population had increased to over 7,000,000 and at the present time, to about 18,000,000. Yet from the earliest recorded history of locust outbreaks (see Uichanco, 1936a) until these more recent times, periodical recurrence of intensity of locust outbreaks appears to have kept on with a fair degree of regularity.

Sex-ratio

The mean sex-ratio of the forty-nine lots studied in the present work is 0.56 ± 0.0035, with a standard deviation of 0.36 ± 0.0025. The mode falls slightly below the mean, but is more than 0.50, as may be seen in chart 10. The coefficient of variation is 6.50 ± 0.44 per cent.

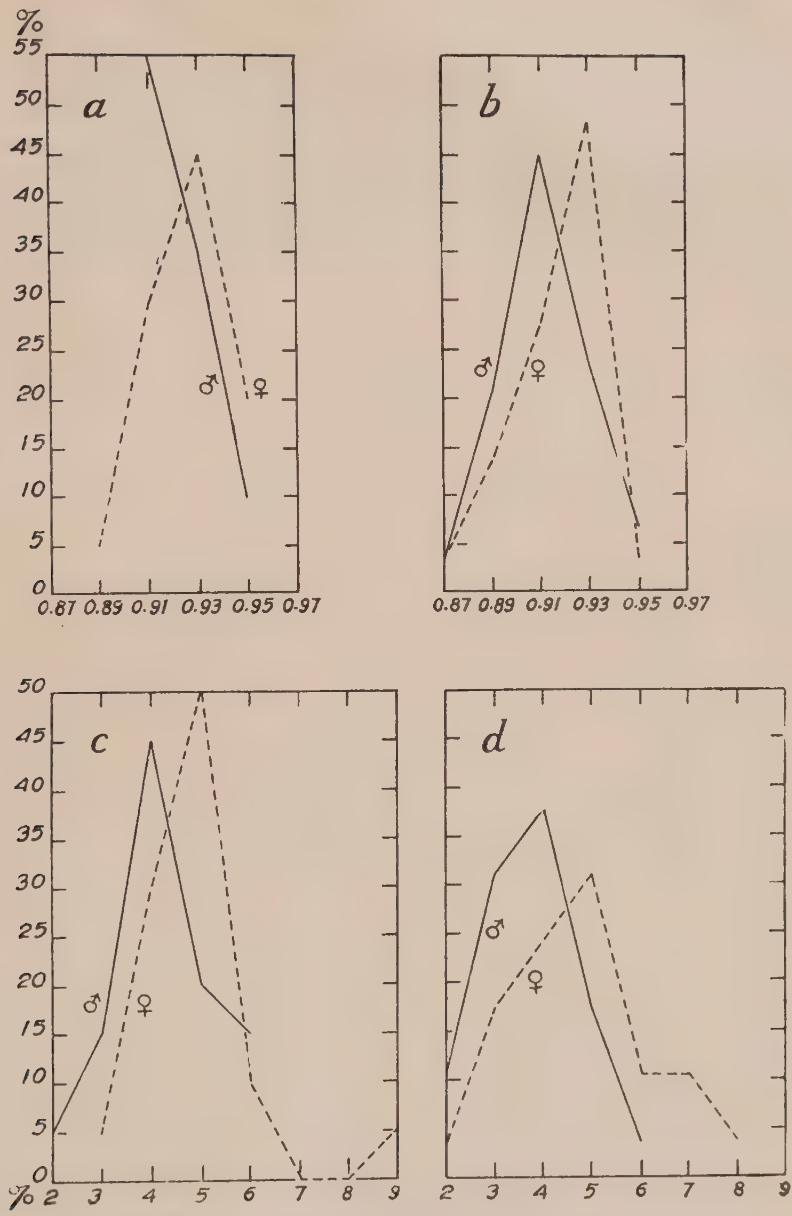

Chart 9.—Per cent distribution of the various lots in terms of H/F (ratio of height of pronotum at point of constriction to length of pronotum along median carina). (*a*) Mean of ratio in months of high infestation; (*b*) in months of low infestation. (*c*) Coefficient of variation in months of high infestation; (*d*) in months of low infestation.

Unfortunately, the ages of the swarms represented by these lots could not be ascertained by us. Hence, we are unable to establish a statistical correlation between the age of swarm and the sex-ratio. The following points, however, taken up in a preliminary report of the old research bureau of the Philippine Sugar Association (mimeographed reports) are of interest in this connection. Report

Chart 10.—Distribution of sex-ratio in forty-nine lots.

of July 25, 1932: On July 18 at Bearin (Negros Occidental) 222 males and 158 females, or sex-ratio of 41.58 per cent, were counted in swarm samples. The locust there was only three weeks old at the time. In older swarms, the females are probably equal to or more than the males, because they live longer. Again in the report of February 20, 1933: The males show preponderance over the females

in the egg pods surveyed—41.03 to 64.29 per cent. In eight egg pods, only one showed more females.

These random observations are in part confirmed by the trend of the curve in chart 10, where the distribution abruptly rises to the left of the mode but meanders along a broad and gradual slope to the right until the highest sex-ratio is reached and thus indicates a rapid falling off of the male components and increasing prevalence of the female in the population of what are presumably progressively older swarms.

SUMMARY AND CONCLUSIONS

1. A total of 49 lots, aggregating 19,619 adult locusts, were studied. These were collected from swarms occurring in various parts of Luzon, Visayas, and Mindanao, during the years 1932, 1933, 1934, 1935, and 1936, around the height of the present outbreak cycle.

2. In all of the pairs of morphological parts considered, the coefficients of correlation were positive and significant and the coefficients of variation of their ratios fairly uniform. In none of them, however, was this coefficient so high as to preclude its use in ratios as criteria for comparison of the trends of swarms under given sets of conditions, in the light of Uvarov's theory of phases. More use was made, however, of A/F and to some extent A/B, because they were derived from morphological parts (tegmen and hind femur) that could be measured more accurately than the others and also because the resulting ratios were sizable integers and not small fractions. Hence, calculated differences were larger and, therefore, easier to detect.

3. A comparison of our figures for *Locusta migratoria manilensis* of exclusively Philippine sources with those recorded by Uvarov (1936) for locust material of this subspecies from both Philippine and extra-Philippine localities shows remarkably close correspondence in the ratios, although some discrepancies were noted in the means of the absolute dimensions of morphological parts.

4. The divergent trends in correlation coefficients of pairs of parts, which in certain cases were significantly higher in the females than in the males, and in others significantly higher in the males than in the females, point to a difference in pleomorphic responses of the two sexes in relation to change in phases. In a number of cases, the ratios of certain morphological parts exhibit a greater variability in the female, while in the male these are relatively more stable.

5. The length of tegmen (A) is quite constant in both sexes, but the length of hind femur (F) is variable. The varying values of A/F are therefore the result of an increase or a decrease in absolute length of the hind femur, rather than of a change in this dimension of the tegmen.

6. No noticeable difference was found in the composition of swarms that are grouped on the basis of relative "susceptibility" or "non-susceptibility" of the localities from which they were collected. The conclusion arrived at is that any place in the Philippines, even if it lies outside what we regard as permanent reservation, may temporarily offer conditions for the formation and casual maintenance of swarms, especially around the peak of the outbreak cycle. A greater environmental resistance in such localities, however, may not permit a protracted continuity therein of locust outbreak. Another, though perhaps subordinate, factor that brings about uniformity in swarm composition is the interisland migration of adult locusts in their swarming activities.

7. Locusts collected from swarms occurring during months of high seasonal infestation (June, July, and August) showed a coefficient of variation for A/F which is significantly higher in the male by 2.58 per cent and in the female by 3.77 per cent than those from swarms occurring during months of low seasonal infestation (September, October, November, December, January, February, March, April, and May). Likewise, the female shows this statistical constant for A/B to be higher by 2.34 per cent in the former sets of months than in the latter. The means of the absolute dimensions of A and B showed no significant difference but that of F was less by 1.22 millimeters in the months of high than in those of low seasonal infestation.

8. A greater or a smaller coefficient of variation for A/F was found to occur in either sex for lots collected in any month, which suggests varying intrusion of the intermediate forms in swarms in any month during the height of the outbreak cycle.

9. Uvarov's theory impliedly regards the gregarious, the solitary, and their two intermediate phases as genetically connected steps in a complete cycle that proceeds in a single direction. Such results in the present paper as marked heterogeneity of swarms, with a bigger aggregate coefficient of variation, during months of high seasonal infestation, and the known persistence of swarms to a greater or less extent in highly susceptible Philippine localities, as in certain parts of Mindanao, cannot be satisfactorily reconciled with that premise.

10. For a more adequate explanation of the trend of locust outbreaks in the Philippines, especially in view of the discrepancies pointed out above, a restatement of Uvarov's theory in a somewhat modified form is suggested. In the proposed modification, the phases are not to be considered as continuous steps in a complete unidirectional cycle; but the female gonad of the locust in any phase contains more than one type of eggs, the survival of one or the other of which is determined by a selective effect of periodically recurring factors of the environment acting upon the body of the mother. The intermediate forms vary in their affinity as regards biological and morphological potentialities toward either the solitary or the gregarious extreme. The height or subsidence of outbreaks is the end-product of these variations. Hence, it would be unnecessary to invoke constantly the existence of a solitary phase in *Locusta migratoria manilensis*, which, under the almost perennial swarm conditions obtaining in certain parts of Mindanao, is rather difficult to visualize.

11. The mean sex-ratio for the forty-nine lots studied is 0.56, with a coefficient of variation of 6.50 per cent. The sex-ratio as an index to age of adult swarm is discussed on the basis of preliminary findings elsewhere.

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TABLE 1

Collection data of lots used

LOT	PLACE OF COLLECTION	DATE	NUMBER OF INDIVIDUALS		SEX-RATIO
			female	*male*	
1	Isabela, Occidental Negros ..	July 22, '32	139	138	.51
2	Kabankalan, Occidental Negros	Aug. 29, '32	143	154	.49
3	Cauayan, Occidental Negros .	Oct. 28, '32	110	152	.42
4	La Carlota, Occidental Negros	Dec. 9, '32	477	458	.51
5	La Carlota, Occidental Negros	Feb. 14, '33	138	83	.63
6	Murcia, Occidental Negros ..	Feb. 24, '33	15	12	.56
7	Isabela, Occidental Negros ...	June 8, '34	17	13	.57
8	Silay, Occidental Negros	June 12, '33	87	90	.49
9	Silay, Occidental Negros	June 28, '33	492	412	.54
10	San Ramon, Zamboanga	July 1, '33	128	48	.73
11	Davao, Davao	July 1, '33	87	58	.60
12	Valladolid, Occidental Negros	Aug. 16, '33	120	72	.63
13	La Carlota, Occidental Negros	Nov. 10, '32	74	22	.77
14	La Carlota, Occidental Negros	Dec. 9, '32	85	84	.52
15	La Carlota, Occidental Negros	Jan. 22, '33	72	53	.58
16	Kabankalan, Occidental Negros	Feb. 12, '33	49	14	.78
17	Kabankalan, Occidental Negros	Mar. 27, '33	38	45	.49
18	Kabankalan, Occidental Negros	April 4, '33	124	111	.53
19	Ormoc, Leyte	Dec. 4, '33	164	94	.64
20	Ormoc, Leyte	Dec. 4, '33	59	37	.62
21	Santander, Cebu	Dec. 8, '33	425	421	.50
22	Cotabato, Cotabato	Dec. 12, '33	482	449	.52
23	Talakag, Bukidnon	Dec. 16, '33	517	512	.50
24	Albay, Albay	Sept. 4, '34	257	253	.51
25	Malaybalay, Bukidnon	Sept. 19, '34	46	82	.36
26	Tayabas, Tayabas	Sept. 4, '34	61	75	.45
27	Surigao, Surigao	Sept. 4, '34	176	40	.84
28	Cebu, Cebu	Sept. 4, '34	171	104	.62
29	Masbate, Masbate	Sept. 4, '34	318	418	.43
30	Cotabato, Cotabato	Sept. 4, '34	349	477	.42
31	Catbalogan, Samar	Sept. 4, '34	340	255	.57
32	Surigao, Surigao	Sept. 4, '34	282	44	.87
33	Jaro, Iloilo	June 1, '35	189	77	.71
34	Albay, Albay	Sept. 4, '34	427	413	.51
35	Tacloban, Leyte	Sept. 4, '34	528	472	.53
36	Pagbilao, Tayabas	June 9, '35	52	82	.39
37	Malvar, Batangas	May 31, '35	177	105	.63
38	Bato, Davao	July 18, '35	497	455	.52
39	Oriental Misamis	Sept. 24 '35	592	478	.49
40	Butuan, Agusan	July 26, '35	325	279	.54
41	Salcedo, Samar	Aug. 3, '35	283	483	.37
42	Madoao, Davao	July 12, '35	322	273	.54
43	Surigao, Surigao	Aug. 12, '35	120	54	.68
44	San Pascual, Burias Island .	July 5, '35	101	50	.67
45	Taal Island, Batangas	July 14, '35	55	72	.43
46	Villaba, Leyte	Oct. 6, '35	266	249	.52
47	Pantao, Surigao	July 6, '36	112	77	.60
48	Iligan Point, Cagayan	July 5, '35	230	248	.48
49	Catbalogan, Samar	June 1, '35	67	87	.44
		Total ..	10,385	9,234	.56

TABLE 2

Summary table of correlation coefficients for all lots

CHARACTERS CORRELATED	MALE	FEMALE	DIFFERENCE
A and B	.3780 ± .0082	.4365 ± .0073	—.0585 ± .0109
A and F	.6533 ± .0055	.6749 ± .0049	—.0216 ± .0074
P and T	.5268 ± .0051	.4037 ± .0056	.1231 ± .0076
M and T	.6747 ± .0039	.4739 ± .0052	.2008 ± .0065
H and T	.6803 ± .0038	.7338 ± .0031	—.0535 ± .0049
H and P	.5826 ± .0047	.4611 ± .0052	.1215 ± .0070

TABLE 3

Summary table of mean ratios for all lots

RATIO	MEAN		STANDARD DEVIATION		COEFFICIENT OF VARIATION	
	male	female	male	female	male	female
A/B	5.807 ± .0106	5.951 ± .0090	.1806 ± .0066	.2005 ± .0076	3.151 ± .1223	3.378 ± .1289
A/F	2.137 ± .0048	2.198 ± .0047	.0779 ± .0015	.0799 ± .0038	3.666 ± .1165	3.646 ± .1784
P/T	1.100 ± .0033	1.091 ± .0025	.0542 ± .0015	.0557 ± .0012	4.882 ± .1266	5.094 ± .0988
M/T	0.903 ± .0021	0.909 ± .0017	.0342 ± .0012	.0357 ± .0008	3.786 ± .1230	3.926 ± .0882
H/T	1.005 ± .0024	1.009 ± .0017	.0465 ± .0013	.0472 ± .0013	4.619 ± .1245	4.659 ± .1225
H/P	0.916 ± .0015	0.922 ± .0015	.0353 ± .0009	.0429 ± .0011	3.851 ± .0994	4.654 ± .1145

TABLE 4

Comparison of means of A/B and of A/F in susceptible and non-susceptible localities

	A/B					
	Male			Female		
	susceptible	non-susceptible	difference	susceptible	non-susceptible	difference
Mean	5.74 ± .054	5.79 ± .091	— .05 ± .106	5.88 ± .063	6.05 ± .060	—.17 ± .087
Standard deviation	.21 ± .038	.38 ± .064	— .17 ± .074	.27 ± .048	.27 ± .043	0 ± .065
Coefficient of variation	3.61 ± .670	6.59 ± 1.110	—2.98 ± 1.300	4.52 ± .813	4.26 ± .685	.26 ± 1.060

	A/F					
	Male			Female		
	susceptible	non-susceptible	difference	susceptible	non-susceptible	difference
Mean	2.13 ± .021	2.11 ± .030	.02 ± .037	2.19 ± .027	2.18 ± .016	.01 ± .032
Standard deviation	.09 ± .015	.13 ± .024	— .04 ± .028	.11 ± .019	.07 ± .012	.04 ± .023
Coefficient of variation	4.06 ± .590	6.11 ± 1.090	—2.05 ± 1.240	5.07 ± .855	3.08 ± .520	1.99 ± 1.00

TABLE 5

Comparison of means of A/B and of A/F in months of high and in months of low infestation

	A/B					
	Male			Female		
	high	low	difference	high	low	difference
Mean	5.85 ± .033	5.72 ± .043	.13 ± .055	5.92 ± .053	6.02 ± .022	— .10 ± .057
Standard deviation	.131 ± .024	.170 ± .030	—.039 ± .037	.207 ± .037	.071 ± .015	.136 ± .040
Coefficient of variation	2.24 ± .404	2.98 ± .537	— .74 ± .671	3.50 ± .633	1.16 ± .248	2.34 ± .678

	A/F					
	Male			Female		
	high	low	difference	high	low	difference
Mean	2.15 ± .021	2.13 ± .010	.02 ± .023	2.19 ± .031	2.15 ± .013	.04 ± .033
Standard deviation	.086 ± .015	.031 ± .007	.055 ± .016	.131 ± .022	.048 ± .010	.083 ± .024
Coefficient of variation	4.00 ± .675	1.42 ± .303	2.58 ± .742	6.00 ± 1.010	2.23 ± .435	3.77 ± .447

TABLE 6

Comparison of means of A, B, and F in months of high and in months of low infestation

	LENGTH OF TEGMEN (A)					
	Male			Female		
	high	low	difference	high	low	difference
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Mean	46.60 ± .235	46.33 ± .260	.27 ± .359	49.79 ± .157	49.62 ± .206	.17 ± .264
Standard deviation	1.84 ± .166	1.49 ± .187	.35 ± .250	1.23 ± .111	1.18 ± .145	.05 ± .183
Coefficient of variation	3.95 ± .362	3.22 ± .405	.73 ± .548	2.48 ± .226	2.38 ± .298	.10 ± .374

TABLE 6 (continued)

	WIDTH OF TEGMEN (B)					
	Male			Female		
	high	low	difference	high	low	difference
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Mean	8.14 ± .026	7.98 ± .042	.35 ± .049	8.41 ± .024	8.32 ± .031	.09 ± .038
Standard deviation	.210 ± .019	.249 ± .030	—.039 ± .360	.187 ± .017	.183 ± .022	.004 ± .026
Coefficient of variation	2.58 ± .228	3.12 ± .372	—.54 ± .442	2.22 ± .197	2.20 ± .262	.02 ± .332

TABLE 6 (continued)

	LENGTH OF FEMUR (F)					
	Male			Female		
	high	low	difference	high	low	difference
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Mean	22.66 ± .081	21.93 ± .123	+.67 ± .147	21.74 ± .081	22.96 ± .116	−1.22 ± .141
Standard deviation	.690 ± .057	.730 ± .087	−.04 ± .104	.687 ± .057	.689 ± .082	− .002 ± .099
Coefficient of variation	3.04 ± .252	3.33 ± .392	−.29 ± .469	3.16 ± .262	3.00 ± .358	.16 ± .447

TABLE 7

Comparison of means of A, B, and F in susceptible and non-susceptible localities

	LENGTH OF TEGMEN (A)					
	Male			Female		
	susceptible	non-susceptible	difference	susceptible	non-susceptible	difference
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Mean	46.36 ± .202	46.56 ± .212	—.20 ± .291	49.64 ± .168	49.90 ± .149	—.26 ± .227
Standard deviation	1.380 ± .151	1.650 ± .188	—.270 ± .241	1.160 ± .127	1.320 ± .128	—.160 ± .180
Coefficient of variation	2.97 ± .326	3.55 ± .346	—.58 ± .479	2.34 ± .256	2.65 ± .258	—.31 ± .361

TABLE 7 (continued)

	WIDTH OF TEGMEN (B)					
	Male			Female		
	susceptible	non-susceptible	difference	susceptible	non-susceptible	difference
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Mean	8.13 ± .029	8.03 ± .037	.10 ± .047	8.40 ± .028	8.35 ± .025	.05 ± .038
Standard deviation	.181 ± .019	.281 ± .027	— .100 ± .033	.193 ± .021	.185 ± .018	.008 ± .028
Coefficient of variation	2.23 ± .236	3.50 ± .324	—1.27 ± .400	2.30 ± .245	2.22 ± .211	.08 ± .323

TABLE 7 (continued)

LENGTH OF FEMUR (F)

	Male			Female		
	susceptible	non-susceptible	difference	susceptible	non-susceptible	difference
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Mean	21.66 ± .078	22.00 ± .119	—.34 ± .145	22.65 ± .096	22.89 ± .118	—.24 ± .156
Standard deviation	.557 ± .060	.768 ± .070	—.211 ± .092	.671 ± .071	.707 ± .063	—.360 ± .095
Coefficient of variation	2.56 ± .273	3.49 ± .309	—.93 ± .412	2.96 ± .316	3.10 ± .275	—.14 ± .419

TABLE 8

Average measurements and ratios compared with Uvarov's (1936) data

	MALE					FEMALE				
	A	F	A/F	P/T	H/T	A	F	A/F	P/T	H/T
	mm.	*mm.*				*mm.*	*mm.*			
Uvarov	4.26	2.08	2.11	1.11	1.10	4.58	2.13	2.16	1.11	1.08
Uichanco and Gines	4.66	2.18	2.14	1.10	1.01	4.95	2.26	2.20	1.09	1.01

TABLE 9

Width of the head (T)—female

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	139	7.82 ± 0.099	9.21 ± 0.896
2	143	7.89 ± 0.088	7.00 ± 0.787
3	110	7.84 ± 0.073	5.73 ± 0.663
4	477	7.77 ± 0.135	11.51 ± 1.240
5	138	7.32 ± 0.075	5.91 ± 0.728
6	15	7.61 ± 0.062	3.65 ± 0.580
7	17	7.61 ± 0.075	4.15 ± 0.700
8	87	7.73 ± 0.089	6.39 ± 0.814
9	492	7.73 ± 0.085	6.75 ± 0.781
10	128	7.76 ± 0.077	5.48 ± 0.698
11	87	7.66 ± 0.087	6.96 ± 0.805
12	120	7.68 ± 0.077	5.39 ± 0.713
13	74	7.33 ± 0.092	7.00 ± 0.892
14	85	7.61 ± 0.082	5.79 ± 0.767
15	72	7.79 ± 0.088	7.13 ± 0.801
16	49	7.30 ± 0.075	5.26 ± 0.724
17	38	7.66 ± 0.094	6.28 ± 0.865
18	124	7.68 ± 0.085	6.10 ± 0.778
19	164	7.61 ± 0.093	7.69 ± 0.864
20	59	7.66 ± 0.078	6.02 ± 0.718
21	425	7.56 ± 0.088	7.09 ± 0.820
22	482	7.64 ± 0.090	7.64 ± 0.837
23	517	7.70 ± 0.077	5.75 ± 0.708
24	257	7.98 ± 0.084	6.03 ± 0.743
25	46	7.21 ± 0.081	6.26 ± 0.798
26	61	7.74 ± 0.079	5.43 ± 0.718
27	176	7.73 ± 0.077	5.75 ± 0.708
28	171	7.83 ± 0.079	5.97 ± 0.712
29	318	7.71 ± 0.081	5.85 ± 0.746
30	349	7.75 ± 0.083	6.14 ± 0.756
31	340	7.47 ± 0.076	5.86 ± 0.722
32	282	7.70 ± 0.083	6.40 ± 0.763
33	189	7.99 ± 0.085	6.32 ± 0.754
34	427	7.95 ± 0.084	6.29 ± 0.750
35	528	7.51 ± 0.083	6.78 ± 0.784
36	52	7.31 ± 0.072	5.27 ± 0.697
37	177	7.93 ± 0.084	6.67 ± 0.746
38	497	7.66 ± 0.091	7.25 ± 0.839
39	592	7.41 ± 0.085	7.51 ± 0.830
40	325	7.56 ± 0.091	7.57 ± 0.851
41	283	7.57 ± 0.075	5.30 ± 0.701
42	322	7.68 ± 0.086	6.61 ± 0.787
43	120	7.56 ± 0.085	6.64 ± 0.792
44	101	7.61 ± 0.088	6.42 ± 0.818
45	55	7.79 ± 0.076	4.80 ± 0.690
46	266	7.62 ± 0.088	6.84 ± 0.816
47	112	7.29 ± 0.082	6.24 ± 0.795
48	230	7.70 ± 0.073	5.28 ± 0.672
49	67	7.14 ± 0.080	6.22 ± 0.793

TABLE 10

Width of pronotum at shoulders (M)—female

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	140	7.23 ± 0.115	10.81 ± 1.140
2	145	7.27 ± 0.083	7.17 ± 0.806
3	109	7.26 ± 0.088	7.21 ± 0.860
4	476	7.18 ± 0.131	12.09 ± 1.308
5	134	6.66 ± 0.075	6.23 ± 0.794
6	14	6.99 ± 0.104	5.42 ± 1.055
7	22	6.82 ± 0.076	5.24 ± 0.790
8	87	6.89 ± 0.079	6.57 ± 0.809
9	487	6.86 ± 0.087	7.96 ± 0.895
10	112	6.93 ± 0.067	4.97 ± 0.684
11	86	6.81 ± 0.079	6.68 ± 0.823
12	112	6.87 ± 0.076	6.38 ± 0.786
13	75	6.74 ± 0.090	7.90 ± 0.942
14	84	6.71 ± 0.090	8.43 ± 0.947
15	71	7.07 ± 0.080	6.46 ± 0.796
16	49	6.67 ± 0.072	5.32 ± 0.765
17	38	6.98 ± 0.080	5.66 ± 0.814
18	124	6.96 ± 0.077	6.12 ± 0.781
19	164	6.76 ± 0.079	6.73 ± 0.829
20	59	6.81 ± 0.076	5.94 ± 0.787
21	426	6.93 ± 0.081	6.68 ± 0.824
22	481	6.85 ± 0.079	6.88 ± 0.820
23	516	6.95 ± 0.077	6.11 ± 0.779
24	257	7.07 ± 0.073	5.70 ± 0.727
25	46	6.30 ± 0.061	4.07 ± 0.685
26	61	6.95 ± 0.088	6.51 ± 0.896
27	176	6.96 ± 0.077	6.17 ± 0.786
28	172	6.92 ± 0.075	5.77 ± 0.763
29	318	6.88 ± 0.073	5.71 ± 0.756
30	349	6.89 ± 0.081	6.98 ± 0.832
31	340	6.95 ± 0.080	6.59 ± 0.812
32	282	6.97 ± 0.086	7.79 ± 0.876
33	189	7.16 ± 0.070	5.25 ± 0.695
34	327	7.12 ± 0.070	5.26 ± 0.696
35	529	6.93 ± 0.080	7.08 ± 0.819
36	52	6.61 ± 0.068	5.28 ± 0.727
37	184	7.16 ± 0.084	6.50 ± 0.828
38	496	6.93 ± 0.086	7.56 ± 0.875
39	577	6.71 ± 0.079	6.61 ± 0.811
40	325	6.84 ± 0.080	7.19 ± 0.832
41	282	7.05 ± 0.088	6.90 ± 0.880
42	321	6.97 ± 0.082	6.73 ± 0.829
43	117	6.90 ± 0.086	7.58 ± 0.877
44	101	6.82 ± 0.083	6.79 ± 0.865
45	55	7.03 ± 0.091	6.94 ± 0.918
46	265	6.98 ± 0.077	6.12 ± 0.780
47	112	6.65 ± 0.084	7.04 ± 0.897
48	230	6.98 ± 0.074	5.69 ± 0.753
49	74	6.52 ± 0.072	5.44 ± 0.784

TABLE 11

Pronotum length (P)—female

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	135	8.84 ± 0.106	8.54 ± 0.849
2	145	8.59 ± 0.117	9.44 ± 0.960
3	109	8.40 ± 0.104	7.89 ± 0.863
4	478	8.66 ± 0.136	11.67 ± 1.127
5	136	8.14 ± 0.088	7.16 ± 0.764
6	15	8.39 ± 0.081	4.07 ± 0.686
7	24	8.33 ± 0.083	5.37 ± 0.710
8	86	8.29 ± 0.093	7.09 ± 0.796
9	492	8.27 ± 0.112	9.41 ± 0.957
10	124	8.33 ± 0.082	5.88 ± 0.701
11	85	8.15 ± 0.094	7.62 ± 0.813
12	119	8.38 ± 0.083	6.06 ± 0.701
13	67	8.33 ± 0.132	9.71 ± 1.122
14	82	8.13 ± 0.100	7.52 ± 0.870
15	71	8.71 ± 0.108	8.73 ± 0.869
16	47	7.46 ± 0.086	5.91 ± 0.814
17	38	8.56 ± 0.108	7.47 ± 0.891
18	122	8.50 ± 0.101	8.04 ± 0.836
19	162	8.24 ± 0.086	6.54 ± 0.735
20	59	8.36 ± 0.095	6.30 ± 0.803
21	424	8.51 ± 0.112	9.17 ± 0.932
22	481	8.42 ± 0.102	8.04 ± 0.857
23	517	8.41 ± 0.096	7.94 ± 0.807
24	256	8.59 ± 0.092	6.94 ± 0.759
25	46	7.69 ± 0.092	6.18 ± 0.851
26	60	8.32 ± 0.079	5.45 ± 0.677
27	176	8.42 ± 0.091	6.58 ± 0.761
28	172	8.25 ± 0.093	6.67 ± 0.795
29	318	8.32 ± 0.091	6.71 ± 0.775
30	349	8.36 ± 0.084	6.33 ± 0.712
31	340	8.35 ± 0.087	6.57 ± 0.739
32	280	8.43 ± 0.085	6.33 ± 0.712
33	189	8.59 ± 0.091	6.65 ± 0.747
34	427	8.57 ± 0.083	6.44 ± 0.688
35	529	8.42 ± 0.092	6.85 ± 0.770
36	52	7.88 ± 0.076	5.19 ± 0.687
37	183	8.44 ± 0.091	7.13 ± 0.760
38	497	8.21 ± 0.107	9.06 ± 0.921
39	558	7.85 ± 0.091	8.12 ± 0.826
40	325	8.15 ± 0.097	8.01 ± 0.833
41	282	8.43 ± 0.083	6.23 ± 0.700
42	321	8.31 ± 0.081	5.94 ± 0.688
43	118	8.25 ± 0.101	7.88 ± 0.862
44	101	7.96 ± 0.092	6.82 ± 0.814
45	54	8.66 ± 0.088	5.46 ± 0.722
46	265	8.36 ± 0.089	7.28 ± 0.758
47	108	8.02 ± 0.095	7.24 ± 0.837
48	230	8.30 ± 0.112	8.48 ± 0.953
49	74	7.90 ± 0.080	6.01 ± 0.717

TABLE 12

Pronotum height (H)—female

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	139	8.09 ± 0.094	8.29 ± 0.825
2	143	7.90 ± 0.102	8.55 ± 0.912
3	110	7.81 ± 0.095	7.87 ± 0.861
4	463	7.96 ± 0.132	11.51 ± 1.204
5	135	7.32 ± 0.078	6.13 ± 0.755
6	15	7.77 ± 0.078	3.63 ± 0.707
7	19	7.68 ± 0.084	4.85 ± 0.772
8	87	7.76 ± 0.089	7.03 ± 0.814
9	489	7.68 ± 0.108	9.58 ± 0.997
10	118	7.72 ± 0.078	5.97 ± 0.712
11	84	7.58 ± 0.091	6.87 ± 0.846
12	109	7.73 ± 0.085	6.54 ± 0.780
13	70	7.48 ± 0.115	9.90 ± 1.083
14	84	7.57 ± 0.098	8.32 ± 0.910
15	72	8.07 ± 0.099	7.92 ± 0.866
16	48	8.24 ± 0.106	7.11 ± 0.907
17	38	7.91 ± 0.100	6.24 ± 0.897
18	123	7.90 ± 0.083	6.59 ± 0.741
19	164	7.64 ± 0.089	6.90 ± 0.823
20	59	7.69 ± 0.077	5.76 ± 0.709
21	422	7.90 ± 0.102	8.34 ± 1.172
22	480	7.73 ± 0.090	7.75 ± 0.826
23	515	7.87 ± 0.081	6.28 ± 0.726
24	256	8.09 ± 0.100	7.98 ± 0.873
25	46	7.06 ± 0.098	6.86 ± 0.986
26	61	7.77 ± 0.084	6.21 ± 0.765
27	174	7.82 ± 0.080	6.27 ± 0.725
28	172	7.76 ± 0.086	6.54 ± 0.780
29	318	7.67 ± 0.079	5.71 ± 0.728
30	347	7.72 ± 0.082	6.31 ± 0.752
31	340	7.65 ± 0.091	7.46 ± 0.839
32	281	7.85 ± 0.087	7.12 ± 0.779
33	189	8.02 ± 0.080	6.11 ± 0.707
34	426	7.91 ± 0.082	6.16 ± 0.734
35	529	7.71 ± 0.090	7.56 ± 0.827
36	52	7.32 ± 0.087	6.14 ± 0.845
37	183	7.96 ± 0.087	6.89 ± 0.775
38	495	7.69 ± 0.090	7.77 ± 0.829
39	579	7.30 ± 0.094	8.30 ± 0.918
40	325	7.54 ± 0.093	7.94 ± 0.869
41	283	7.83 ± 0.084	5.97 ± 0.761
42	322	7.74 ± 0.089	7.21 ± 0.809
43	120	7.66 ± 0.070	5.78 ± 0.650
44	101	7.53 ± 0.085	6.73 ± 0.802
45	55	7.94 ± 0.099	6.70 ± 0.886
46	266	7.64 ± 0.095	8.45 ± 0.879
47	112	7.43 ± 0.094	7.72 ± 0.893
48	231	7.75 ± 0.096	7.53 ± 0.871
49	74	7.32 ± 0.084	6.14 ± 0.812

TABLE 13

Length of tegmen (A)—female

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	107	50.63 ± 0.473	7.47 ± 0.656
2	88	50.75 ± 0.316	5.84 ± 0.441
3	86	50.23 ± 0.263	5.43 ± 0.370
4	325	51.02 ± 0.519	10.55 ± 0.726
5	30	47.91 ± 0.358	4.56 ± 0.527
6	10	48.87 ± 0.367	3.51 ± 0.528
8	6	48.22 ± 0.437	3.29 ± 0.641
9	207	49.09 ± 0.486	3.88 ± 0.700
13	26	48.18 ± 0.323	4.43 ± 0.472
14	67	49.26 ± 0.350	5.37 ± 0.502
15	32	51.21 ± 0.401	5.56 ± 0.553
16	18	47.46 ± 0.351	3.97 ± 0.525
17	11	50.10 ± 0.380	3.18 ± 0.536
18	36	—	—
19	44	48.88 ± 0.421	5.42 ± 0.607
20	21	49.69 ± 0.420	4.85 ± 0.597
21	278	48.69 ± 0.296	4.41 ± 0.430
22	278	49.41 ± 0.346	5.07 ± 0.494
23	312	49.07 ± 0.249	3.36 ± 0.358
24	187	51.76 ± 0.235	3.79 ± 0.325
25	25	47.07 ± 0.211	2.73 ± 0.316
26	27	49.66 ± 0.290	3.96 ± 0.412
27	10	49.37 ± 0.459	3.64 ± 0.657
28	51	50.51 ± 0.376	4.27 ± 0.526
29	227	49.86 ± 0.418	4.49 ± 0.594
30	247	50.36 ± 0.306	4.22 ± 0.429
31	194	48.83 ± 0.348	5.17 ± 0.503
32	63	50.25 ± 0.264	4.03 ± 0.371
33	66	51.20 ± 0.241	3.88 ± 0.333
34	35	51.21 ± 0.238	4.91 ± 0.328
35	313	49.07 ± 0.282	4.96 ± 0.406
36	10	47.09 ± 0.294	3.59 ± 0.442
37	81	51.01 ± 0.246	4.79 ± 0.341
38	298	49.91 ± 0.244	4.69 ± 0.345
39	339	47.13 ± 0.237	5.23 ± 0.353
40	164	49.70 ± 0.237	4.25 ± 0.338
41	217	50.79 ± 0.537	4.42 ± 0.745
42	147	49.97 ± 0.494	6.38 ± 0.697
43	42	48.92 ± 0.364	4.93 ± 0.526
44	47	48.98 ± 0.362	4.24 ± 0.522
45	23	50.54 ± 0.342	3.62 ± 0.479
46	191	49.90 ± 0.288	4.10 ± 0.408
47	36	48.03 ± 0.482	5.94 ± 0.708
48	140	49.87 ± 0.501	5.57 ± 0.710

TABLE 14

Length of femur (F)—female

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	107	24.20 ± 0.267	7.32 ± 0.781
2	88	22.98 ± 0.192	7.22 ± 0.591
3	86	22.36 ± 0.159	6.77 ± 0.504
4	325	23.38 ± 0.223	8.94 ± 0.675
5	30	21.80 ± 0.203	4.76 ± 0.655
6	10	22.99 ± 0.174	3.18 ± 0.536
7	23	22.20 ± 0.202	4.48 ± 0.644
8	6	21.85 ± 0.376	5.71 ± 1.218
9	207	22.43 ± 0.461	6.81 ± 1.453
10	110	22.52 ± 0.181	5.18 ± 0.567
11	75	21.97 ± 0.204	5.99 ± 0.655
12	97	22.38 ± 0.153	4.96 ± 0.483
13	26	21.93 ± 0.162	4.66 ± 0.524
14	67	21.88 ± 0.266	8.62 ± 0.857
15	32	23.97 ± 0.173	5.36 ± 0.511
16	18	21.58 ± 0.114	3.04 ± 0.375
17	36	23.04 ± 0.219	5.62 ± 0.659
18	112	22.96 ± 0.243	7.01 ± 0.729
19	44	22.42 ± 0.193	5.40 ± 0.607
20	21	22.70 ± 0.169	4.29 ± 0.528
21	278	23.06 ± 0.138	4.05 ± 0.423
22	278	22.85 ± 0.221	6.72 ± 0.681
23	312	23.08 ± 0.162	4.55 ± 0.498
24	187	23.68 ± 0.160	5.30 ± 0.478
25	25	21.33 ± 0.184	4.62 ± 0.612
26	27	22.87 ± 0.158	3.97 ± 0.489
27	153	22.69 ± 0.162	4.95 ± 0.503
28	51	22.48 ± 0.233	5.95 ± 0.733
29	227	22.38 ± 0.199	4.17 ± 0.630
30	247	22.60 ± 0.218	5.70 ± 0.680
31	194	22.77 ± 0.224	5.84 ± 0.815
32	63	22.79 ± 0.155	4.73 ± 0.481
33	66	23.50 ± 0.162	4.80 ± 0.488
34	357	23.51 ± 0.146	5.50 ± 0.437
35	313	22.97 ± 0.162	5.00 ± 0.497
36	10	22.14 ± 0.168	4.21 ± 0.536
37	81	23.37 ± 0.156	5.15 ± 0.473
38	298	22.80 ± 0.168	6.00 ± 0.522
39	584	21.44 ± 0.149	6.56 ± 0.492
40	164	22.21 ± 0.198	6.00 ± 0.625
41	217	23.38 ± 0.263	4.99 ± 0.793
42	147	23.08 ± 0.243	5.85 ± 0.746
43	42	22.60 ± 0.210	5.70 ± 0.659
44	47	21.84 ± 0.258	6.31 ± 0.835
45	23	23.41 ± 0.187	3.94 ± 0.567
46	191	22.77 ± 0.215	5.94 ± 0.668
47	36	21.10 ± 0.307	7.14 ± 1.024
48	140	23.03 ± 0.250	6.41 ± 0.765
49	62	21.97 ± 0.199	4.94 ± 0.610

TABLE 15

Width of tegmen (B)—female

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
3	182	8.35 ± 0.084	6.00 ± 0.716
4	338	8.36 ± 0.162	13.50 ± 1.627
5	70	7.88 ± 0.089	6.23 ± 0.794
6	10	8.19 ± 0.073	3.25 ± 0.633
8	34	8.19 ± 0.092	5.74 ± 0.790
9	250	8.32 ± 0.090	5.99 ± 0.763
11	26	8.33 ± 0.093	5.72 ± 0.788
12	20	8.46 ± 0.081	4.03 ± 0.680
13	44	8.07 ± 0.088	5.85 ± 0.774
14	73	8.29 ± 0.096	7.03 ± 0.813
15	31	8.54 ± 0.087	6.00 ± 0.716
16	38	8.00 ± 0.076	4.70 ± 0.676
17	14	8.34 ± 0.090	4.79 ± 0.761
18	34	8.35 ± 0.087	5.81 ± 0.740
19	108	8.37 ± 0.094	7.23 ± 0.791
20	38	8.46 ± 0.078	4.91 ± 0.649
21	325	8.20 ± 0.084	6.23 ± 0.721
22	324	8.39 ± 0.094	7.38 ± 0.935
23	281	8.39 ± 0.072	4.62 ± 0.611
24	211	8.76 ± 0.089	6.19 ± 0.716
25	43	8.14 ± 0.086	5.19 ± 0.748
26	52	8.34 ± 0.077	5.13 ± 0.654
27	73	8.51 ± 0.081	5.12 ± 0.677
28	97	8.51 ± 0.075	4.89 ± 0.623
29	268	8.57 ± 0.079	4.73 ± 0.651
30	291	8.58 ± 0.089	6.54 ± 0.735
31	176	8.33 ± 0.086	6.10 ± 0.727
32	163	8.47 ± 0.100	7.43 ± 0.835
33	126	8.54 ± 0.088	6.13 ± 0.730
34	377	8.71 ± 0.093	6.50 ± 0.531
35	371	8.34 ± 0.084	6.12 ± 0.708
36	16	8.24 ± 0.093	5.57 ± 0.801
37	95	8.57 ± 0.105	7.28 ± 0.869
38	346	8.38 ± 0.100	7.41 ± 0.857
39	529	8.05 ± 0.098	8.07 ± 0.813
40	253	8.23 ± 0.101	8.14 ± 0.868
41	227	8.57 ± 0.073	4.17 ± 0.600
42	198	8.37 ± 0.091	6.42 ± 0.767
43	82	8.24 ± 0.098	7.27 ± 0.841
44	88	8.15 ± 0.095	6.27 ± 0.829
45	47	8.61 ± 0.111	6.33 ± 0.910
46	227	8.47 ± 0.088	6.91 ± 0.737
47	78	7.97 ± 0.099	7.79 ± 0.876
48	140	8.50 ± 0.098	6.60 ± 0.813
49	8	8.28 ± 0.106	5.04 ± 0.908

TABLE 16

Width of the head (T)—male

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	138	7.30 ± 0.102	9.95 ± 0.990
2	154	7.48 ± 0.076	5.66 ± 0.721
3	152	7.34 ± 0.073	5.49 ± 0.700
4	458	7.12 ± 0.091	8.23 ± 0.901
5	83	6.43 ± 0.070	5.37 ± 0.741
6	12	6.80 ± 0.088	5.43 ± 0.916
7	13	7.10 ± 0.085	5.32 ± 0.843
8	90	7.13 ± 0.086	6.68 ± 0.853
9	412	7.16 ± 0.078	6.25 ± 0.769
10	48	7.24 ± 0.065	4.20 ± 0.633
11	58	7.13 ± 0.065	4.88 ± 0.646
12	72	7.26 ± 0.078	6.34 ± 0.756
13	22	6.88 ± 0.132	9.00 ± 1.357
14	84	7.20 ± 0.076	5.42 ± 0.746
15	53	7.13 ± 0.091	7.36 ± 0.907
16	14	6.63 ± 0.072	4.27 ± 0.770
17	45	7.05 ± 0.070	4.89 ± 0.703
18	111	7.14 ± 0.081	6.51 ± 0.802
19	94	7.11 ± 0.072	5.44 ± 0.720
20	37	7.10 ± 0.073	5.06 ± 0.728
21	421	6.94 ± 0.094	8.49 ± 0.954
22	449	6.96 ± 0.088	7.93 ± 0.891
23	512	7.18 ± 0.085	7.06 ± 0.842
24	253	7.47 ± 0.080	5.71 ± 0.756
25	82	7.72 ± 0.075	5.61 ± 0.691
26	75	7.22 ± 0.084	6.07 ± 0.803
27	40	7.10 ± 0.067	5.00 ± 0.661
28	104	7.37 ± 0.078	5.85 ± 0.746
29	418	7.27 ± 0.078	6.35 ± 0.757
30	477	7.29 ± 0.085	7.34 ± 0.825
31	255	6.85 ± 0.079	6.63 ± 0.816
32	44	7.21 ± 0.079	5.62 ± 0.774
33	77	7.46 ± 0.071	5.07 ± 0.671
34	413	7.44 ± 0.062	4.48 ± 0.593
35	472	6.93 ± 0.089	7.88 ± 0.912
36	82	7.80 ± 0.087	6.20 ± 0.791
37	105	7.27 ± 0.078	6.16 ± 0.759
38	455	7.13 ± 0.090	7.04 ± 0.897
39	478	6.85 ± 0.077	6.73 ± 0.832
40	279	7.05 ± 0.090	7.80 ± 0.902
41	483	7.14 ± 0.083	6.91 ± 0.825
42	273	7.07 ± 0.089	7.24 ± 0.892
43	54	6.97 ± 0.092	7.07 ± 0.935
44	50	7.09 ± 0.090	6.50 ± 0.895
45	72	7.28 ± 0.082	6.23 ± 0.794
46	249	7.16 ± 0.089	6.90 ± 0.879
47	77	6.80 ± 0.088	7.15 ± 0.911
48	248	7.15 ± 0.082	7.02 ± 0.812
49	87	7.77 ± 0.078	5.78 ± 0.712

TABLE 17

Width of pronotum at shoulders (M)—male

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	136	6.75 ± 0.087	8.12 ± 0.913
2	153	6.89 ± 0.077	6.45 ± 0.794
3	152	6.70 ± 0.082	7.46 ± 0.863
4	459	6.55 ± 0.104	9.96 ± 1.120
5	85	6.05 ± 0.077	7.03 ± 0.896
6	12	6.23 ± 0.078	5.27 ± 0.889
7	17	6.27 ± 0.069	4.86 ± 0.773
8	89	6.32 ± 0.090	7.64 ± 1.011
9	211	6.36 ± 0.083	7.54 ± 0.929
10	44	6.47 ± 0.065	4.70 ± 0.709
11	59	6.32 ± 0.075	6.34 ± 0.839
12	74	6.46 ± 0.075	5.94 ± 0.818
13	22	6.35 ± 0.092	6.09 ± 1.027
14	83	6.30 ± 0.081	6.84 ± 0.905
15	54	6.46 ± 0.075	6.23 ± 0.824
16	14	6.02 ± 0.077	5.36 ± 0.904
17	46	6.35 ± 0.070	5.66 ± 0.779
18	111	6.45 ± 0.067	5.35 ± 0.737
19	94	6.31 ± 0.080	6.54 ± 0.900
20	37	6.30 ± 0.076	5.94 ± 0.854
21	421	6.37 ± 0.080	7.47 ± 0.891
22	449	6.21 ± 0.079	7.08 ± 0.902
23	512	6.47 ± 0.070	5.79 ± 0.766
24	253	6.60 ± 0.064	4.79 ± 0.689
25	82	6.80 ± 0.075	6.15 ± 0.784
26	75	6.40 ± 0.066	4.83 ± 0.728
27	40	6.51 ± 0.064	4.86 ± 0.699
28	104	6.54 ± 0.071	5.06 ± 0.765
29	416	6.44 ± 0.082	7.60 ± 0.906
30	478	6.48 ± 0.073	5.82 ± 0.801
31	255	6.31 ± 0.081	6.91 ± 0.914
32	44	6.51 ± 0.065	4.72 ± 0.712
33	76	6.67 ± 0.067	4.68 ± 0.705
34	412	6.63 ± 0.062	5.03 ± 0.667
35	470	6.34 ± 0.076	6.84 ± 0.842
36	82	7.09 ± 0.068	4.91 ± 0.675
37	105	6.56 ± 0.065	4.90 ± 0.705
38	454	6.43 ± 0.076	6.54 ± 0.833
39	482	6.10 ± 0.070	6.13 ± 0.812
40	279	6.36 ± 0.083	7.26 ± 0.926
41	488	6.63 ± 0.079	6.64 ± 0.846
42	273	6.42 ± 0.077	6.91 ± 0.850
43	54	6.35 ± 0.092	7.13 ± 1.025
44	50	6.31 ± 0.083	6.77 ± 0.932
45	72	6.63 ± 0.065	5.01 ± 0.690
46	249	6.56 ± 0.070	5.40 ± 0.743
47	77	6.18 ± 0.072	6.28 ± 0.831
48	248	6.50 ± 0.076	7.14 ± 0.825
49	109	7.03 ± 0.086	6.59 ± 0.872

TABLE 18

Pronotum length (P)—male

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	134	8.18 ± 0.109	9.69 ± 0.943
2	151	8.05 ± 0.088	6.91 ± 0.777
3	152	7.87 ± 0.105	9.10 ± 0.946
4	446	8.02 ± 0.109	10.09 ± 1.009
5	81	7.47 ± 0.075	5.56 ± 0.709
6	12	7.64 ± 0.097	5.65 ± 0.899
7	17	7.66 ± 0.095	5.22 ± 0.881
8	90	7.65 ± 0.094	7.27 ± 0.867
9	408	7.66 ± 0.085	7.36 ± 0.786
10	47	7.81 ± 0.090	5.40 ± 0.814
11	59	7.67 ± 0.083	6.44 ± 0.768
12	76	7.93 ± 0.087	5.67 ± 0.781
13	17	7.71 ± 0.101	6.43 ± 0.925
14	80	7.72 ± 0.081	6.00 ± 0.739
15	53	8.14 ± 0.090	6.94 ± 0.780
16	13	7.67 ± 0.088	4.50 ± 0.811
17	46	7.92 ± 0.096	7.40 ± 0.856
18	107	7.92 ± 0.088	6.75 ± 0.781
19	93	7.80 ± 0.088	6.49 ± 0.799
20	37	7.74 ± 0.082	5.44 ± 0.749
21	416	7.22 ± 0.084	7.09 ± 0.820
22	447	7.73 ± 0.093	7.58 ± 0.852
23	513	7.86 ± 0.082	6.89 ± 0.735
24	252	8.16 ± 0.081	6.08 ± 0.703
25	82	8.26 ± 0.094	6.74 ± 0.804
26	74	7.72 ± 0.074	4.91 ± 0.675
27	39	7.86 ± 0.097	6.58 ± 0.870
28	104	7.91 ± 0.077	5.39 ± 0.687
29	416	7.87 ± 0.093	7.66 ± 0.838
30	478	7.25 ± 0.087	7.58 ± 0.852
31	254	7.75 ± 0.092	7.26 ± 0.840
32	44	7.88 ± 0.089	5.32 ± 0.802
33	77	8.03 ± 0.091	6.30 ± 0.803
34	411	8.04 ± 0.092	7.18 ± 0.807
35	471	7.83 ± 0.095	8.04 ± 0.858
36	82	8.37 ± 0.099	7.00 ± 0.835
37	105	7.79 ± 0.091	7.34 ± 0.825
38	455	7.67 ± 0.102	9.06 ± 0.943
39	480	7.34 ± 0.091	8.22 ± 0.877
40	288	7.70 ± 0.101	8.28 ± 0.931
41	487	8.00 ± 0.090	7.05 ± 0.793
42	272	7.74 ± 0.088	6.52 ± 0.803
43	52	7.76 ± 0.093	6.87 ± 0.846
44	50	7.47 ± 0.122	9.04 ± 1.152
45	72	8.17 ± 0.090	6.34 ± 0.782
46	249	7.95 ± 0.089	6.20 ± 0.790
47	75	7.49 ± 0.087	7.13 ± 0.825
48	247	7.76 ± 0.094	8.24 ± 0.858
49	110	8.46 ± 0.084	5.90 ± 0.703

TABLE 19

Pronotum height (H)—male

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	138	7.52 ± .110	10.85 ± 1.051
2	153	7.49 ± .077	5.89 ± .725
3	152	7.30 ± .089	8.04 ± .857
4	461	7.28 ± .092	8.13 ± .890
5	83	6.61 ± .078	6.53 ± .832
6	12	6.90 ± .148	7.13 ± 1.521
7	15	7.04 ± .094	5.23 ± .943
8	91	7.10 ± .086	7.17 ± .855
9	411	7.08 ± .087	7.53 ± .870
10	42	7.23 ± .102	6.94 ± .998
11	59	7.03 ± .082	6.46 ± .823
12	76	7.32 ± .078	5.74 ± .759
13	19	7.02 ± .125	7.46 ± 1.258
14	84	7.13 ± .079	6.17 ± .788
15	54	7.34 ± .085	6.21 ± .822
16	14	6.79 ± .081	5.03 ± .848
17	46	7.27 ± .083	6.14 ± .812
18	110	7.28 ± .080	6.75 ± .781
19	94	7.11 ± .073	5.68 ± .724
20	37	7.09 ± .071	5.12 ± .705
21	419	7.90 ± .071	5.46 ± .614
22	448	7.02 ± .085	7.42 ± .856
23	513	7.27 ± .084	7.27 ± .817
24	253	7.42 ± .079	5.91 ± .753
25	82	7.67 ± .081	6.30 ± .751
26	74	7.22 ± .073	5.22 ± .719
27	40	7.26 ± .073	5.37 ± .710
28	104	7.36 ± .078	6.08 ± .749
29	418	7.17 ± .083	6.89 ± .821
30	477	7.89 ± .087	6.97 ± .784
31	255	7.02 ± .089	7.31 ± .900
32	44	7.26 ± .086	6.08 ± .837
33	77	7.48 ± .081	5.83 ± .771
34	413	7.37 ± .075	5.65 ± .720
35	472	7.13 ± .091	8.07 ± .907
36	82	7.86 ± .088	6.22 ± .793
37	105	7.28 ± .083	6.77 ± .807
38	454	7.14 ± .073	6.29 ± .775
39	480	6.80 ± .080	7.19 ± .832
40	279	7.03 ± .087	7.30 ± .870
41	489	7.39 ± .080	6.41 ± .764
42	273	7.13 ± .090	7.52 ± .897
43	54	7.12 ± .102	7.98 ± 1.017
44	50	6.94 ± .106	8.80 ± 1.084
45	72	7.48 ± .082	5.89 ± .779
46	248	7.17 ± .082	6.33 ± .807
47	77	6.95 ± .093	7.69 ± .947
48	248	7.19 ± .086	7.72 ± .843
49	110	7.91 ± .079	5.32 ± .704

TABLE 20

Length of tegmen (A)—male

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	110	47.71 ± .558	8.68 ± .828
2	91	48.56 ± .216	4.12 ± .315
3	98	47.19 ± .223	4.74 ± .333
4	335	46.78 ± .256	5.55 ± .386
5	17	43.07 ± .480	5.48 ± .788
6	8	44.63 ± .610	5.06 ± .853
8	11	46.55 ± .309	2.95 ± .469
9	210	45.07 ± .246	2.56 ± .386
10	10		
13	8	45.19 ± .460	4.27 ± .720
14	47	46.65 ± .342	4.60 ± .517
15	25	47.28 ± .340	4.89 ± .509
16	6	42.65 ± .502	4.27 ± .831
17	8	46.46 ± .364	2.85 ± .554
19	21	46.70 ± .342	4.35 ± .519
20	5	46.44 ± .410	2.91 ± .623
21	259	46.55 ± .195	2.56 ± .296
22	269	45.02 ± .349	5.27 ± .548
23	314	46.57 ± .266	4.33 ± .405
24	167	48.33 ± .216	3.91 ± .315
25	47	49.77 ± .325	4.84 ± .462
26	29	46.93 ± .269	3.91 ± .406
27	6	46.45 ± .383	2.73 ± .583
28	25	48.01 ± .353	3.95 ± .523
29	84	47.43 ± .405	5.66 ± .604
30	307	47.76 ± .245	4.49 ± .362
31	156	45.34 ± .369	4.98 ± .575
32	15	49.97 ± .318	3.01 ± .478
33	24	47.86 ± .229	3.10 ± .339
34	325	48.07 ± .212	4.38 ± .311
35	274	45.67 ± .317	5.44 ± .490
36	19	50.46 ± .452	4.20 ± .633
37	32	47.36 ± .229	3.36 ± .342
38	292	46.87 ± .212	4.28 ± .319
39	380	43.45 ± .265	6.28 ± .432
40	156	46.64 ± .252	4.60 ± .376
41	264	47.30 ± .329	4.49 ± .491
42	134	45.99 ± .376	4.92 ± .587
43	12	46.33 ± .548	5.54 ± .836
44	24	45.54 ± .538	7.23 ± .853
45	31	47.38 ± .393	4.60 ± .586
46	152	46.83 ± .381	4.98 ± .576
47	20	44.72 ± .499	6.20 ± .790
48	134	46.57 ± .324	4.00 ± .493

TABLE 21

Length of femur (F)—male

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
1	110	23.10 ± .305	8.79 ± .933
2	91	22.41 ± .149	5.66 ± .470
3	98	21.66 ± .169	6.84 ± .551
4	335	22.24 ± .174	7.61 ± .554
5	17	20.52 ± .243	5.28 ± .816
6	8	21.18 ± .254	4.71 ± .847
7	17	21.25 ± .175	4.06 ± .584
8	11	21.69 ± .134	2.74 ± .436
9	210	20.44 ± .205	4.20 ± .708
10	40	21.58 ± .166	4.29 ± .547
11	51	21.09 ± .203	5.96 ± .670
12	58	21.89 ± .170	4.90 ± .551
13	8	20.80 ± .247	4.65 ± .838
14	47	21.32 ± .165	4.86 ± .547
15	25	22.43 ± .191	5.36 ± .602
16	6	20.25 ± .238	4.31 ± .839
17	44	21.82 ± .183	4.94 ± .589
18	106	22.00 ± .184	5.39 ± .590
19	21	21.77 ± .144	3.91 ± .467
20	37	21.46 ± .181	4.84 ± .596
21	259	22.19 ± .129	3.56 ± .412
22	269	21.18 ± .179	5.45 ± .596
23	314	22.27 ± .172	4.79 ± .554
24	167	22.77 ± .137	3.89 ± .426
25	47	22.22 ± .208	6.68 ± .664
26	29	22.06 ± .160	4.39 ± .508
27	38	21.87 ± .177	4.79 ± .571
28	25	22.29 ± .192	4.42 ± .609
29	284	21.70 ± .245	6.49 ± .799
30	307	21.91 ± .137	4.83 ± .443
31	156	21.70 ± .196	5.35 ± .638
32	15	21.83 ± .183	4.10 ± .590
33	24	22.59 ± .197	4.85 ± .618
34	325	22.60 ± .142	5.34 ± .443
35	274	21.77 ± .165	5.52 ± .537
36	19	23.22 ± .298	5.37 ± .906
37	32	21.95 ± .156	4.23 ± .505
38	292	21.61 ± .146	5.49 ± .478
39	467	20.25 ± .143	6.16 ± .497
40	156	21.47 ± .190	6.00 ± .625
41	264	22.42 ± .230	5.88 ± .724
42	134	21.81 ± .294	6.90 ± .950
43	12	21.52 ± .348	6.78 ± 1.143
44	24	21.02 ± .285	6.67 ± .959
45	31	22.62 ± .259	5.36 ± .808
46	152	21.79 ± .197	5.36 ± .639
47	20	20.94 ± .269	6.00 ± .903
48	134	21.72 ± .200	5.12 ± .652
49	86	22.68 ± .219	6.08 ± .683

TABLE 22

Width of the tegmen (B)—male

LOT	FREQUENCY	MEAN	COEFFICIENT OF VARIATION
		mm.	*per cent*
3	62	8.07 ± .083	5.93 ± .730
4	324	7.99 ± .103	8.78 ± .914
5	46	7.40 ± .089	6.90 ± .850
6	6	7.57 ± .069	3.29 ± .641
8	38	7.94 ± .112	7.24 ± .997
9	243	7.93 ± .065	3.86 ± .582
11	16	8.00 ± .081	3.98 ± .717
12	15	8.25 ± .080	4.06 ± .685
13	14	7.82 ± .119	5.96 ± 1.074
14	58	8.10 ± .085	5.81 ± .741
15	24	8.20 ± .088	5.95 ± .759
16	7	7.44 ± .065	2.92 ± .623
17	15	7.89 ± .070	3.46 ± .624
18	34	8.02 ± .077	4.09 ± .563
19	58	8.01 ± .081	5.41 ± .714
20	20	8.14 ± .086	4.68 ± .744
21	275	7.89 ± .083	5.86 ± .747
22	308	7.90 ± .082	6.13 ± .731
23	358	8.14 ± .085	6.57 ± .739
24	196	8.39 ± .083	5.51 ± .702
25	69	8.39 ± .095	6.51 ± .800
26	57	8.07 ± .090	5.94 ± .786
27	94	8.09 ± .099	5.46 ± .867
28	48	8.27 ± .081	5.26 ± .696
29	346	8.29 ± .087	6.81 ± .745
30	383	8.32 ± .094	7.49 ± .799
31	143	7.97 ± .090	6.29 ± .802
32	281	8.06 ± .082	4.98 ± .716
33	51	8.27 ± .092	5.74 ± .791
34	363	8.35 ± .079	5.64 ± .672
35	313	7.98 ± .090	7.28 ± .797
36	34	8.53 ± .089	4.08 ± .735
37	44	8.13 ± .099	6.02 ± .866
38	329	8.08 ± .089	6.89 ± .775
39	441	8.04 ± .105	7.97 ± .922
40	214	7.95 ± .088	6.60 ± .786
41	269	8.26 ± .082	4.88 ± .702
42	154	7.96 ± .097	6.26 ± .862
43	27	7.94 ± .142	8.41 ± 1.269
44	39	7.78 ± .123	7.75 ± 1.114
45	56	8.26 ± .089	5.95 ± .760
46	216	8.15 ± .100	7.91 ± .867
47	54	7.66 ± .096	7.90 ± .888
48	160	8.09 ± .106	6.45 ± .928
49	12	8.56 ± .143	6.05 ± 1.178

TABLE 23

A comparison of coefficients of variation of A/F in the various lots according to season

LOT NUMBER	LOCALITY	DATE COLLECTED	COEFFICIENT OF VARIATION	
			male	female
	months of low infestation		*per cent*	*per cent*
3	Cauayan, Occidental Negros .	Oct. 28, 1932	3.43	2.26
13	La Carlota, Occidental Negros	Nov. 10, 1932	4.45	3.79
4	La Carlota, Occidental Negros	Dec. 9, 1932	6.65	4.27
14	La Carlota, Occidental Negros	Dec. 9, 1932	3.36	2.64
15	La Carlota, Occidental Negros	Jan. 22, 1933	2.63	2.74
16	Kabankalan, Occidental Negros	Feb. 12, 1933	3.22	3.89
5	La Carlota, Occidental Negros	Feb. 14, 1933	5.47	3.57
6	Murcia, Occidental Negros ...	Feb. 24, 1933	4.86	3.03
17	Kabankalan, Occidental Negros	Mar. 27, 1933	3.35	1.23
18	Kabankalan, Occidental Negros	April 4, 1933	2.98	4.21
19	Ormoc, Leyte	Dec. 4, 1933	2.58	4.67
20	Ormoc, Leyte	Dec. 4, 1933	3.29	4.37
21	Santander, Cebu	Dec. 8, 1933	3.28	6.22
22	Cotabato, Cotabato	Dec. 12, 1933	4.76	2.81
23	Talakag, Bukidnon	Dec. 16, 1933	3.57	9.50
26	Tayabas, Tayabas	Sept. 4, 1934	3.96	2.62
24	Albay, Albay	Sept. 4, 1934	4.42	1.15
34	Albay, Albay	Sept. 4, 1934	2.14	7.30
31	Catbalogan, Samar	Sept. 4, 1934	3.81	4.73
29	Masbate, Masbate	Sept. 4, 1934	3.17	3.25
28	Cebu, Cebu	Sept. 4, 1934	1.86	3.06
35	Tacloban, Leyte	Sept. 4, 1934	3.14	3.49
27	Surigao, Surigao	Sept. 4, 1934	2.36	2.34
32	Surigao, Surigao	Sept. 4, 1934	4.01	6.63
30	Cotabato, Cotabato	Sept. 4, 1934	2.90	1.14
25	Malaybalay, Bukidnon	Sept. 19, 1934	2.89	2.06
37	Malvar, Batangas	May 31, 1935	3.49	2.57
39	Oriental Misamis	Sept. 24, 1935	4.46	7.23
46	Villaba, Leyte	Oct. 6, 1935	3.05	3.26
	months of high infestation			
1	Isabela, Occidental Negros ...	July 22, 1932	5.21	2.90
2	Kabankalan, Occidental Negros	Aug. 29, 1932	5.13	4.14
8	Silay, Occidental Negros	June 12, 1933	1.73	4.47
9	Silay, Occidental Negros	June 28, 1933	3.22	2.28
11	Davao, Davao	July 1, 1933	1.31	2.10
12	Valladolid, Occidental Negros.	Aug. 16, 1933	5.16	1.11
7	Isabela, Occidental Negros ...	June 8, 1934	5.21	0.73
49	Catbalogan, Samar	June 1, 1935	3.40	
33	Jaro, Iloilo	June 1, 1935	3.09	2.98
36	Pagbilao, Tayabas	June 9, 1935	3.09	2.22
48	Iligan Point, Cagayan	July 5, 1935	3.21	4.02
44	San Pascual, Burias Island ...	July 5, 1935	7.55	1.23
42	Madoao, Davao	July 12, 1935	3.87	4.71
45	Taal Island, Batangas	July 14, 1935	3.28	3.02
38	Bato, Davao	July 18, 1935	2.86	3.56
40	Butuan, Agusan	July 26, 1935	4.92	3.48
41	Salcedo, Samar	Aug. 3, 1935	3.41	5.98
43	Surigao, Surigao	Aug. 12, 1935	2.95	6.83
47	Pantao, Surigao	July 6, 1936	3.84	5.58

TABLE 24[a]

Grass and open land in proportion to total area in the Philippines

PROVINCE	TOTAL AREA	GRASS AND OPEN LAND	
Mindanao and Sulu	*hectares*	*hectares*	*per cent*
Agusan	1,112,146	4,580	0.41
Davao	1,929,724	31,180	1.62
Cotabato	2,491,580	344,547	13.83
Bukidnon	821,874	368,279	44.81
Surigao	757,401	7,597	1.00
Lanao	631,701	52,745	8.35
Misamis Oriental	270,905	43,548	16.08
Misamis Occidental	176,580	14,189	8.03
Zamboanga	1,653,197	120,112	7.27
Sulu	280,238	38,025	13.57
Mean			11.50
Visayas			
Bohol	397,824	189,916	47.74
Siquijor	31,857	7,817	24.54
Romblon	130,795	21,821	16.68
Leyte	778,295	61,062	7.85
Masbate	400,155	242,185	60.52
Negros Oriental	460,761	140,302	30.45
Negros Occidental	809,375	123,092	15.21
Antique	261,849	99,607	38.04
Capiz	442,890	145,750	32.91
Iloilo	528,360	196,941	37.27
Cebu	483,553	209,042	43.23
Samar	1,355,606	72,590	5.35
Mean			29.98
Southeastern Luzon and adjacent islands, and Palawan			
Sorsogon	186,501	4,015	2.16
Albay	255,285	37,842	14.82
Catanduanes	147,112	2,028	1.38
Camarines Norte	200,785	247	0.12
Camarines Sur	536,609	60,052	11.19
Tayabas	1,214,511	32,328	2.66
Marinduque	92,204	5,221	5.66
Mindoro	1,017,352	279,753	27.50
Palawan	1,455,321	78,264	5.38
Mean			7.87

[a] Data rearranged from figures for December 31, 1933, of the Bureau of Forestry.

TABLE 24 (continued)

PROVINCE	TOTAL AREA	GRASS AND OPEN LAND	
Relatively non-susceptible provinces (Luzon)	*hectares*	*hectares*	*per cent*
Batanes	19,166	9,056	47.25
Cagayan	854,853	149,661	17.51
Isabela	1,085,268	206,591	19.04
La Union	113,768	35,411	31.13
Ilocos Norte	334,887	86,358	25.79
Ilocos Sur	262,211	129,361	49.34
Bontoc	221,096	71,647	32.40
Benguet and Baguio	270,177	184.364	68.24
Apayao	399,817	46,678	11.67
Kalinga	296,196	204,451	69.03
Ifugao	214,836	129,194	60.14
Abra	382,025	145,554	38.10
Pangasinan	504,171	56,961	11.30
Zambales	368,039	160,487	43.61
Nueva Ecija	541,706	169,637	31.32
Nueva Vizcaya	684,395	124,221	18.15
Tarlac	301,392	135,155	44.84
Bataan	124,320	2,417	1.94
Bulacan	260,983	36,026	13.80
Pampanga	210,187	23,293	11.08
Rizal and Manila	236,467	134,624	56.93
Cavite	120,176	61,070	50.82
Laguna	186,398	66,621	35.74
Batangas	325,170	140,384	43.17
Mean			34.68

THE USE OF FISH MEAL IN DUCK RATIONS FOR EGG PRODUCTION [1]

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The favorable results of an experiment carried on in the College of Agriculture some eight years ago on the value of dried shrimps and fish meal as possible substitutes for snails in duck rations for egg production encouraged us to continue our studies along this line. These results showed that either dried shrimps or fish meal may be satisfactorily used as a substitute for snails in the feeding of ducks. It was shown that for egg production, dried shrimps was the best supplement, fish meal, second, and snails, the poorest. The study, incidentally, demonstrated that it was not necessary to be located near a large body of fresh water to raise ducks for profit (Cruz, 1932).

In the present paper, the results of a recent study conducted in the College of Agriculture are being reported. Rations containing different amounts of fish meal were compared to determine at what level this supplement may be introduced for best results. Fish meal was used, instead of shrimp meal, because this product is more readily available to many duck raisers than shrimp meal, the supply of which is markedly seasonal in many localities.

Four lots containing thirty-five laying ducks and three drakes each were used in this study. Lot I, which received a supplement of 20 per cent shrimp meal, was used as a check. This amount was found by Cruz (1932) to be the best for egg production. The different lots were given the following rations:

FEEDS USED	LOT I	LOT II	LOT III	LOT IV
Shrimp meal	20.0	—	—	—
Fish meal	—	20.0	30.0	40.0
Corn meal	20.0	20.0	17.5	15.0
Rice bran	60.0	60.0	52.5	45.0
Price per 100 kgm.	₱ 6.31	₱ 5.00	₱ 5.75	₱ 6.31

To every 100 kilograms of each of the mash mixtures studied, one kilogram of common table salt and two kilograms of ground shell

[1] Experiment Station contribution No. 1180. Read in the Fourth Philippine Science Convention, February 23 to 27, 1937.

were added. Chopped green grass was given to each lot morning and afternoon. The feed was given wet four times a day: twice in the morning, at about six and at about ten o'clock, and twice in the afternoon, at about two and at about four o'clock. They were given in each feeding time as much feed as they were able to consume in about twenty minutes. The only water to which the birds had access at all times was drinking water, which was changed four or five times a day.

It will be noted in table 1 that, in spite of the fact that no water where the ducks could swim was available, all of the four lots studied laid eggs regularly throughout the year. There was no time when the ducks stopped laying, as is normally experienced by local duck raisers during periods when there is a scarcity of snails or when snails are difficult to get because of continuous rough weather. During such times, duck raisers who are totally dependent upon snails for feed supplement hardly get any egg for periods ranging from two to five months or even more. In the present study, at no time did egg production drop to less than 25 per cent.

In terms of the number of eggs produced, the lot that received a supplement of 30 per cent fish meal in the ration (lot III) was observed to be the best, with an average of 50.4 per cent egg production; in actual eggs laid, 184.0 each bird a year. Lot IV, fed 40 per cent fish meal, averaged 48.8 per cent, or 179.3 eggs each, and lot II, 20 per cent fish meal, 45.5 per cent or 164.6 eggs each a year. Contrary to previous experience, lot I which received 20 per cent shrimp meal had an average production of only 43.7 per cent, or 159.2 eggs a year. Apparently, the quality of the fish meal used in the present study was very much better than that used by Cruz (1932), so that it compared very favorably with shrimp meal.

The average amount of feed consumed by each bird in the different lots was as follows: Lot I (20 per cent shrimp meal), 47.4 kgm.; lot II (20 per cent fish meal), 47.6 kgm.; lot III (30 per cent fish meal), 50.1 kgm.; and lot IV (40 per cent fish meal), 48.4 kgm. At this rate, it needed 3.9 kgm. of feeds to produce a dozen eggs in the lot that received 20 per cent shrimp meal in the ration, 3.8 kgm. in the lot that received 20 per cent fish meal, and 3.6 kgm. in the other two lots. Because of the differences in the cost of the rations, the most economical eggs were produced by lot II (20 per cent fish meal lot), the cost of feeds needed to produce a dozen eggs in this lot being 19.0 centavos. In lot III (30 per cent fish meal), the cost was 20.6 centavos; and in lot IV (40 per cent fish meal), 23.2 centavos. The

most expensive eggs were produced by lot I (20 per cent shrimp meal); the cost was 24.6 centavos.

While no unfavorable effects of the rations tested were noted on the ducks, lot IV, which received 40 per cent fish meal in the ration, had the highest mortality, this being 28.9 per cent, and the lots that received only 20 per cent supplement in the ration, lots I and II, had the lowest, 13.2 per cent. Lot III, 30 per cent fish meal, was intermediate with a mortality during the year of 23.7 per cent. Apparently, a supplement of 40 per cent fish meal in a ration for laying ducks was too much for their well-being.

Another observation worth noting in this study was the color of the yolk and the flavor of the eggs produced. The color of the yolk varied from light yellow to deep yellow. On the other hand, the eggs of ducks raised near Laguna de Bay and which depend upon snails for protein supplement in the feed, have yolks that are deep orange in color. The taste and color of the duck eggs produced in this study compared favorably with those of chicken eggs. For this reason, the eggs produced found a ready local sale when sold as fresh eggs.

The results obtained in this study again demonstrated that ducks may be raised profitably away from a large body of fresh water. This is contrary to the prevailing opinion of local duck raisers who contend that ducks, being aquatic in their habits, may be raised profitably only near a lake or stream where there are plenty of snails. The distribution of the egg production of all the lots studied was, in fact, probably considerably better than that experienced by any local duck raiser.

Fear has been expressed during the last few years that the duck industry is on the decline. As a result of his observations, Manalo (1936) pointed out the following as some of the causes: (*a*) the high cost of production owing to scarcity of snails and the difficulty of locating them; (*b*) the presence of large flocks of wild ducks which were credited with the unerring instinct of locating the richest snail beds in the duck-raising districts; and (*c*) the excessive duck population in the region. One encouraging note brought about by the present study is that duck raisers would not have to depend upon snails for profitable production.

SUMMARY AND CONCLUSIONS

1. On the basis of number of eggs produced, a ration containing a supplement of 30 per cent fish meal was observed to produce the

best results. Contrary to expectations, the lot that received a supplement of 20 per cent shrimp meal produced the least number of eggs.

2. There were no significant differences observed in the amounts of feeds needed to feed a laying duck a year. This amount ranged from 47.4 kgm. in the lot that received a supplement of 20 per cent in the ration to 50.1 kgm. in the lot that received 30 per cent fish meal.

3. Because of the differences in the prices of the rations tested, the most economical eggs were produced by the lot that received a supplement of 20 per cent fish meal, namely, lot II. In this lot, it required feeds costing only 19.0 centavos to produce a dozen eggs. This lot was followed by lot III, 30 per cent fish meal, 20.6 centavos. The most expensive eggs were produced in the lot that received a supplement of 20 per cent shrimp meal, 24.6 centavos.

4. The lots that received a protein supplement of 20 per cent, lots I and II, had the lowest mortality during the year, 13.2 per cent; lot IV, 40 per cent fish meal lot, the highest, 28.9 per cent.

5. The results of this experiment give further proofs that duck raisers do not have to depend upon snails to carry on their enterprise profitably.

6. The best amount of supplement to use for economical production of eggs was 20 per cent fish meal. For the production of the largest number of eggs, a supplement of 30 per cent fish meal proved the best.

7. In the present study it is shown that it is not necessary to be located near a large body of fresh water to raise ducks for profit. In spite of the fact that no water where the ducks could swim was available, all of the four lots of ducks studied laid eggs regularly throughout the year.

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CRUZ, GAUDENCIO B. 1932. Studies on the methods of feeding ducks. The Philippine Agriculturist 20: 535–548. *Chart 1.*

MANALO, PEDRO S. 1936. Is the duck industry doomed? Agricultural and Industrial Monthly (February): 18, 29, 43.

TABLE 1

Percentage egg production of ducks raised inland and given rations supplemented with varying amounts of fish meal.

PERIODS COVERED	LOT I 20% shrimp meal	LOT II 20% fish meal	LOT III 30% fish meal	LOT IV 40% shrimp meal
1935	*per cent*	*per cent*	*per cent*	*per cent*
June 14 – July 13 ...	42.0	34.1	53.7	40.6
July 14 – Aug. 13 ...	36.1	34.0	52.0	63.3
Aug. 14 – Sept. 13 ...	28.4	26.1	25.9	45.4
Sept. 14 – Oct. 13 ...	27.6	29.5	29.6	37.0
Oct. 14 – Nov. 13 ...	42.1	51.7	58.4	54.4
Nov. 14 – Dec. 13 ...	52.7	67.8	64.6	60.0
1936				
Dec. 14 – Jan. 13 ...	49.7	58.2	50.4	55.8
Jan. 14 – Feb. 13 ...	58.8	64.6	63.8	59.5
Feb. 14 – Mar. 13 ...	60.5	58.8	72.4	53.4
Mar. 14 – Apr. 13 ...	58.4	51.3	51.5	45.5
Apr. 14 – May 13 ...	40.5	37.4	43.7	37.3
May 14 – June 13 ...	27.1	32.0	39.2	33.8
Average	43.7	45.5	50.4	48.8

ANTHER COLOR AND MALE FERTILITY IN SUGAR CANE [1]

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In sugar cane hybridization work, it is desirable to obtain as many varietal combinations as possible to produce a maximum degree of variations on which to base selection. A practical method of crossing sugar cane, the so-called free crossing, consists in placing the arrows intended to be male just over the tassels of female-to-be parent plant. In this way the number of hybrid seedlings obtained varies among other factors with the relative percentage of pollen fertility of the male parent and cross-compatibility of the varieties crossed. Hunter and Leake (1933), in discussing the importance of pollen fertility in sugar cane breeding, remark that "when the percentage of fertile pollen falls below 40, it is considered necessary to take special precautions where the objective is self-fertilization; where, however, cross-fertilization is desired, the direction of the cross will be determined by the relative capacities of the two varieties to set viable pollen, the mother parent being that having the lower percentage of viable pollen". Pollen fertility is, therefore, one of the major factors responsible for the success of sugar-cane varietal crossing. Since the quality of pollen is best judged by iodine test through microscopical examination, it is evident that a knowledge of morphological characters correlated with the reaction of pollen to iodine would facilitate the choice of male tassels.

Bannier (1926) describes the method of determining the fertility of sugar cane pollen by iodine reaction. By this method, Bannier classifies the fertility of thirty-one sugar-cane varieties at the sugar-cane experiment station at Pasoeroean, Java. Among other factors that strongly influence the fertility of pollen, Bannier mentions soil types, rainfall, and humidity.

Bregger (1933) studied the relation of anther color and iodine reaction of pollen of seventeen sugar cane varieties in Rio Piedras, Puerto Rico, during the arrowing season of 1930. He concludes that within rather wide limits there is a positive relationship between

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[1] Read at the general meeting of the Fourth Philippine Science Convention held at Canlubang, Laguna, February 26, 1937. Experiment Station contribution No. 1181. Received for publication May 10, 1937.

pollen fertility as indicated by iodine test and the degree of anther coloration in the sugar cane.

This investigation was planned with the object of determining the relation between the color of anther and male fertility within a variety of sugar cane. The studies were conducted during the cane-arrowing season of 1935-1936 which covered the period from September, 1935 to January, 1936.

MATERIALS AND METHODS

Sugar cane varieties used. The materials used in this investigation were a number of the flowering cane varieties and hybrids grown in the plant breeding garden of the College of Agriculture. These sugar-cane varieties include the following:

Philippine seedling varieties

(1) C. A. C. 87
(2) C. A. C. 114
(3) C. A. C. 117
(4) C. A. C. 126
(5) C. A. C. 128
(6) C. A. C. 130
(7) C. A. C. 131
(8) C. A. 12735
(9) C. A. 12797
(10) C. A. 14797
(11) C. N. 18712
(12) Hind's Special
(13) Lamao White

Foreign varieties

(1) Co. 205
(2) Co. 210
(3) Co. 213
(4) Co. 214
(5) D-1135
(6) H-109
(7) H-227
(8) H-8965
(9) P. O. J. 228
(10) P. O. J. 2714
(11) P. O. J. 2722
(12) P. O. J. 2727
(13) P. O. J. 2878
(14) P. O. J. 2883
(15) Q-409
(16) Q-426
(17) Badila
(18) Delagrabe
(19) Lahaina
(20) Mauritius Malagache
(21) Uba de Natal

Experimental procedure. At about the mid-period of the cane arrowing season, that is, in the month of November when most varieties showed signs of tasseling, the colors of the anthers of these flowering varieties were critically examined and recorded. The determination of the colors of the anthers was done at the time of anthesis at which stage they were easily discernible. This generally occurs very early in the morning, usually at dawn. The corresponding iodine reaction of the pollen of the varieties studied was then determined as follows: Early in the morning, between 5:30 and 6:30 o'clock, the spikelets from the base, mid-portion, and tip of the cane

inflorescence were cut off, put in vials containing water, and taken to the laboratory. These branchlets, or spikelets, were then shaken over a slide. Thereafter, a microscopical preparation of pollen was made by staining some pollen with a drop of solution of iodine in potassium iodide. The pollen counts of those giving positive reaction were then made and recorded. Positive reaction indicates starch-filled pollen grains or pollen fertility while negative reaction indicates infertile or non-viable grains. Fertile pollen grains containing a large amount of starch are large and rounded and they stain dark blue; infertile pollen grains are usually small, often shrivelled or shrunken, and they produce a faint yellow or straw color with iodine. The percentage of iodine-positive pollen grains for each variety examined was based upon the number of grains actually observed and counted on a given microscopical field. The percentage serves as an index of the condition of the pollen sampled from different parts of the cane inflorescence. In determining statistically the coefficient of correlation between anther colors and percentages of iodine-positive pollen grains, the numerical class values of the former were arbitrarily formed by assigning a quantitative value according to intensity of purple anthocyan to each of anther colors. The yellow anthers with a slight tinge of purple was evaluated 1; the light purple or medium purple, 2; and the dark purple anthers, 3.

RESULTS AND DISCUSSION

The sugar cane varieties studied in this experiment possess mainly two colors of anthers, the purple and the non-purple. Of the purple class we have the dark purple and the light or medium purple anthers. The non-purple anthers are not strictly devoid of purple pigmentation, but appear light yellow or brownish yellow, with a slight tinge of purple. Under field conditions the non-purple anthers can be easily classified as yellow or light yellow.

The relation of anther color and iodine reaction of the thirty-four sugar cane varieties studied is shown in table 1. The data in this table seem to show that intensity of purple coloration of the anthers is some indication of the fertility of the pollen grains enclosed therein. The dark purple-anthered varieties gave a range of variation of 61 to 90 per cent iodine-positive pollen grains, with a mean of 73.00 $\pm$ 2.34 per cent. The light purple-anthered canes gave a range of 48 to 79 per cent and a mean of 64.00 $\pm$ 1.44 per cent. The non-purple or yellow-anthered varieties gave the least percentage of iodine-positive grains, the range of variation being 16 to 43 per cent and the mean, 30.00 $\pm$ 2.53 per cent. The distribution with

regard to these floral characters indicates that, in general, the more intense the purple color, the higher the mean percentage of iodine-positive grains of the corresponding anther-colored varieties. The purple-anthered canes contained significantly higher percentage of starch filled grains and, hence, were more fertile than the non-purple ones. Some of the varieties and hybrids studied in this work had behaved differently in other countries. In Java, Bannier (1926) reports that P. O. J. 2714 possessed complete sex sterility, the ovary being infertile and the anthers shedding no pollen grain. In the present study P. O. J. 2714 gave 35 per cent fertile pollen. It is possible that climatic conditions, for example, rainfall and humidity, may account for this variation in sexual expression, for these factors exert a decided influence on cane tasseling. Moreover, the method of sampling from an arrow may in part account for the discovery of fertile pollen in this particular variety, for in sugar cane, Mendiola (1926) mentions Rios who reports that in a panicle, or arrow, which ordinarily contains perfect flowers, there may be found only either male or female flowers. In Puerto Rico, during the 1931 arrowing season, Bregger (1933) found that Co. 213 gave 26.4 per cent and P. O. J. 2883, zero per cent iodine-positive. Under College conditions during the arrowing period covered by the present study, Co. 213 gave 61 per cent and P. O. J. 2883, 43 per cent fertile pollen. These apparent variations in pollen fertility exhibited by the same variety may be explained in part by climatic and soil conditions, different years of observation, and differences in flowering periods within a given geographical locality. It may be mentioned also in this connection that the experimental technique followed in Puerto Rico differs from that which was adopted in the present investigation. In Puerto Rico, Bregger (1933) cut the cane arrows in the late afternoon, brought them to the laboratory, and preserved them overnight in 6 per cent sulfurous acid sufficient to approximate a 1:3000 solution. The next morning, pollen samples were collected on slides and examined microscopically in a saturated solution of iodine in chloral hydrate. In the present experiment, pollen obtained from spikelets were apparently fresh, being secured a few minutes before examination in solution of iodine in potassium iodide. Bregger (1933) further observed that, in the case of variety SC12-4, the anthers were dark purple and gave 90 per cent iodine-positive when they were gathered from field grown plants, while when grown in drums the anthers became medium purple and gave 57 per cent fertile pollen. This seems to show that the color of anthers is in some way affected by the condition under which plants are raised.

The data on the variations in anther color and percentage of male fertility were distributed in a correlation table (see table 2). The coefficient of correlation obtained was 0.784 ± 0.045. This coefficient indicates a high degree of association between purple pigmentation and starch content of pollen grains. The close relationship of anther color and pollen fertility was, according to Bregger (1933), not affected by seasons of planting, for the correlation coefficient he obtained in Puerto Rico between the observations made in November, 1931 and in August, 1932 was 0.642 ± 0.059.

From the foregoing, it may be safely concluded that, based on microscopical and statistical evidences, a positive correlation exists between pollen fertility as indicated by iodine reaction and anther color of sugar cane. Accordingly, in free-crossing work, as between purple and yellow anthered cane, other things being equal, the former, which gave a higher percentage of male fertility than the latter, are to be preferred as male tassels, or pollinators.

SUMMARY OF CONCLUSIONS

1. A close relationship between pollen fertility as indicated by iodine reaction and intensity of anther pigmentation exists in the thirty-four sugar cane varieties grown in the College of Agriculture.

(a) Purple-anthered canes gave a mean of 73.00 ± 2.34 per cent; light purple-anthered varieties, 64.00 ± 1.44 per cent; and the non-purple or light yellow-anthered ones, 30.00 ± 2.53 per cent iodine-positive pollen.

(b) The correlation coefficient, 0.784 ± 0.045, between these two characters is positive and highly significant.

2. Since anther color is significantly correlated with male fertility in varietal crossing of sugar cane, the choice of male tassels, other characters being satisfactory, should consequently be for the purple-anthered varieties which generally give a high percentage of pollen fertility.

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TABLE 1

Distribution of iodine-positive pollen among cane varieties with purple and non-purple anthers

VARIETY	GRAINS STUDIED	IODINE-POSITIVE		
		dark purple	light purple	yellow
	number	*per cent*	*per cent*	*per cent*
C. A. C. 126	284	70	—	—
C. A. C. 128	136	69	—	—
C. A. C. 117	271	90	—	—
C. A. 14797	183	61	—	—
Q-409	158	70	—	—
D-1135	140	71	—	—
Co. 214	121	79	—	—
C. A. C. 130	185	—	48	—
C. A. C. 131	213	—	67	—
C. A. C. 114	243	—	79	—
C. A. C. 87	123	—	65	—
C. A. 12735	127	—	63	—
P. O. J. 2878	155	—	71	—
M. Malagache	144	—	77	—
H-109	230	—	62	—
H-227	140	—	78	—
Co. 213	128	—	61	—
Co. 210	110	—	60	—
P. O. J. 2727	108	—	65	—
P. O. J. 228	79	—	47	—
H-8965	204	—	62	—
Q-426	134	—	78	—
P. O. J. 2722	110	—	51	—
C. N. 18712	98	—	61	—
Hind's Special	100	—	67	—
C. A. 12797	198	—	68	—
Badila	102	—	53	—
Lamao White	81	—	—	40
Delagrabe	70	—	—	32
Co. 205	62	—	—	21
P. O. J. 2883	121	—	—	43
P. O. J. 2714	66	—	—	35
Lahaina	152	—	—	16
Uba de Natal	150	—	—	26
	Range	61 — 90	48 — 79	16 — 43
	Mean	73.0 ± 2.34	64.0 ± 1.44	30 ± 2.53

TABLE 2

Correlation between anther pigmentation and per cent iodine-positive pollen grains

PER CENT IODINE-POSITIVE

	v.	11–20	21–30	31–40	41–60	51–60	61–70	71–80	81–90	f
Anther color	1	1	2	3	1	—	—	—	—	7
	2	—	—	—	2	3	10	5	—	20
	3	—	—	—	—	—	4	2	1	7
	f	1	2	3	3	3	14	7	1	34

$r = 0.784 \pm 0.045$

ÜBER DIE PHYSIKALISCHEN UND CHEMISCHEN EIGENSCHAFTEN DES WEISSEN BODENS IM BERGE MAQUILING, LOS BAÑOS, LAGUNA [1]

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Sehr verbreitet ist die Ansicht, dass weisser Boden reich an Kali ist. Auch es ist ein bekannter Erfahrungssatz der Agrikulturchemie, dass die physikalischen und chemischen Eigenschaften für die Beurteilung des Gutes eines Bodens massgebend sind. Ausgehend von der Kenntnisse der physikalischen und chemischen Beschaffenheit eines Bodens, so erhaelt man ein klares und übersichtliches Bild, das von grosser Bedeutung für die Bearbeitung des Bodens und für die Dasseinsmöglichkeit der Mikroorganismen ist.

Der weisse Boden im Berge Maquiling tritt ausnahmlos nur in den höher gelegenen Gebieten auf und zwar entsteht durch die Verwitterung der vulkanischen Tuffe. Diese Gesteine sind bekanntlich Lockerprodukte, die von dem Vulkan ausgeworfen und spaeter aus Luft oder Wasser abgesezt werden. Ihrer Faerbung halber wird er abgebaut, mit Wasser behandelt, in Stangen geformt getrocknet und verkauft. Der mit Wasser behandelte Boden dient in diesem Orte zur Herstellung der Ultramarin, Tünche, Schreibkreide usw. Cox (1907) hatte den Boden der keramischen Untersuchungen unterworfen.

Untersuchungen dieses Bodens vom Standpunkte des Landwirts liegen meines Wissens bisher nicht vor, so dass es sich trotz aller theoretischen Erwaegungen in der Hauptsache doch nur um ein spekulatives Wissen handelt, dem keine Erfahrungstatsachen stützend zur Seite stehen.

Die vorliegende Arbeit bezweckte daher die Ermittlung derjenigen Eigenschaften, welche für das Pflanzenwachstum sowie für die Bodenbearbeitung in Betracht kommen können. Zur naeheren Kennzeichnung dieses Bodens wurden die Bodenproben zunaechst hinsichtlich ihrer physikalischen und chemischen Beschaffenheit untersucht.

Zum Versuch standen mir zwei Bodenproben zur Verfügung und zwar kam nur lufttrockener Boden unter 2 mm. Korngrösse. Eine

[1] Mitteilung der Versuchtsstation Nr. 1182. Eingegangen. 17, Maerz 1937.

von den wurde von mir in dem lokalen Handel gekauft. Die andere wurde von Herrn Instructor F. Soliven, Department of Agricultural Chemistry, nebst seinen Studenten in Agricultural Chemistry 120, und Herrn Forester V. Caguioa, Bureau of Forestry, in dem Schuljahr 1934-1935, im Berge Maquiling, entnommen. Die beiden Proben stellten einen schweren Boden von grauer Faerbung dar und zeigten gegen Lakmus neutrale Reaktion.

Bevor ich in die Mitteilung der Untersuchungsergebnisse der analysierten Bodenproben eintrette, ist es mir angenehme Pflicht auch an dieser Stelle diesen Herren meinen besten Dank auszusprechen.

EXPERIMENTELLER TEIL

Die mechanische Zusammensetzung wurde nach dem Vorbilde von Vageler und Alten (1931) ermittelt, wie es von Galvez (1934) ausgeführt wurde. Die Wasserhaltendekapazitaet und die Hygroskopizitaet wurden nach den von Weissmann angegebenen Vorschriften bestimmt; ihr Gehalt an Bodenkolloide, nach dem Vorgange von Bouyoucos (1927).

Die chemische Zusammensetzung wurde im grossen und ganzen nach dem von Wahnschaffe und Schucht (1924) vorgeschriebenen Verfahren durchgeführt und zwar erstrechten sie auf die Ermittlung des Gehalts an wichtigen Bodenkonstituenten. Der Naehrstoffvorrat wurde auf Grund der Salzsaeureauszüge erhalten. Das benutzte Verfahren war die von Blanck und Rieser (1928) 10-prozentige empholene Salzsaeuremethode. Die aufnahmbare Phosphorsaeure und das leicht lösliche Kalium wurden nach der Zitronensaeuremethode von Lemmermann-Fresenius (1932) bestimmt; ihr Gehalt an Glühverlust und Gesamtstickstoff, nach dem Vorgange der Association of Agricultural Chemists (1930) und die organischen Substanz, nach der Methode-Nostitz (1936).

Über die physikalischen und chemischen Eigenschaften dieser Bodenproben unterrichten die in Tabelle 1 bis 3 wiedergegebenen Zahlen. Dieselben sind auf "wasserfreie Substantz" umgerechnet angegeben und stehen jeweils das Mittel aus zwei gut übereinstimmenden Einzelbestimmungen dar.

BESPRECHUNG DER ERGEBNISSE

Aus den angeführten Tabelle 1 laesst sich erkennen, dass grosse Mengen des Bodenmaterials in der Schlaemmfraktion enthalten sind. Die Menge des Tons, d. h. der Fraktionanteil deren Korngrösse unter 0,002 mm. ist, betraegt im Durchschnitt 50,25 Prozent. Nach Blanck und Haselhoff (1928) sind die Kapillaren in diesem Anteil

so klein, dass er selbst nicht nur die Bewegung der Mikroorganismen unterdrückt sondern auch die kapillare Wasserbewegung sehr behindert. Dieser Anteil macht den Hauptbestandteil der Tonböden. Dagegen ist die kapillare Wasserbewegung in dem Schluff als gut zu bezeichnen. Aber bei Kompakter Lagerung wurden die Kapillare zu klein um den Wurzeln genügend Platz liefern zu können. Der untersuchte Boden enthaelt im Durchschnitt 44,55 Prozent davon. Der Schluff gibt den Hauptanteil sehr vieler Lehm-und Tonböden. Hinsichtlich des Sands ist ihre Gesamtmenge zu unbedeutend um die physikalischen Beschaffenheit dieses Bodens beeinflussen zu können.

An und für sich laesst sich feststellen, dass ihre Wasserkapazitaet sehr gross ist. Dieser höhe Wert ist wohl auf das Vorhandensein der grossen Mengen der feinsten Bodenteilchen zurückzuführen. Nach Mitscherlich (1905) ist die Wasserkapazitaet eines Bodens um so grosser, je feiner die festen Bodenteilchen sind. Betrachtet man die Hygroskopizitaet, so sieht man, dass sie mit dem Gehalt an Kolloide zusammenhaengt. Dies bedeutet eine Bestaetigung der von Giesecke (1927) zitierten Anschauung, über das Verhaeltnis zwischen Hygroskopizitaet und Kolloide.

Aus den in Tabelle 2 wiedergegebenen Zahlen, geht wieder auf das deutlichste hervor, dass die chemische Zusammensetzung der untersuchten Bodenproben fast einem völlig reinen Ton entspricht, der nur geringe Spuren von Beimengungen führte. Hierdurch finden die von Cox(1907) angegebenen Analysenwerte der weissen Böden in der Provinz Laguna eine Bestaetigung. Die darin enthaltenen Beimengungen sind Titan, Eisen, Erdalkalien, Alkalien, Schwefel und Phosphor. Die Anwesenheit von Eisen könnte durch Glühen beweisen werden. Dadurch nimmt der Boden eine hellbraune Farbe an. Diese Feststellung dürfte wohl den verhaeltnismassig höhen Wert der Hygroskopizitaet dieses Bodens zum Teil erklaeren. Im Zusammenhang mit diesem Befunde ist noch auf das von Giesecke(1927) gefundene Ergebnis hinzuweisen, das besagt, dass der Hygroskopizitaetszhalt von dem Verhaeltnis Sesquioxide : SiO_2 beeinflusst wird und zwar je weiter dies Verhaeltnis wird, desto wird die Hygroskopizitaet verkleinert.

Der Ausfall der chemischen Analyse entspricht durchaus dem mechanischen Aufbau der Bodenproben. Demzufolge ist der Boden als Tonboden anzusprechen.

Vielfach wird angenommen, dass die in 10-prozentiger Salzsaeure löslichen Naehrstoffe ein annahernder Masstab des Nahrstoffvorrats eines Bodens sind. Kawe(1932), Galvez(1936), u. a. vertretten

diese Ansicht. Ausgehend von diesem Punkt sei zunaechst die analytischen Befunden der Salzsaeureauszüge, des Stickstoffs ebenso der organischen Substanz kurz erörtert. Wie aus den Tabelle 3 zu ersehen ist, enthaelt die Salzsaeureauszüge dieser Proben alle unbedingten notwendigen Naehrstoffe. Bemerkenswert ist noch, dass die nach der 10-prozentigen Salzsaeuremethode erhaltenen Werte ziemlich niedrig sind. Jedoch gilt dies nicht für alle Stoffe, denn der Boden erweist sich hiernach als sehr reich an Phosphorsaeure- und Schwefelsaurereserve. Dennoch zeigt sich bei den beiden Bodenproben, dass der Stickstoff und die organischen Substanz nicht zugegen sind. Bezüglich der Abwesenheit dieser Bodenmaterialien ist daraufhinzuweisen, dass der weisse Boden im Berge Maquiling nur in der Naehe von Mudspring vorkommt. In diesem Gebiete ist das Temperatur für das Vorhandensein der organischen Substanz nicht angenehm.

Zum naeheren Verstandnis ist es aber erförderlich die Menge der durch 1-prozentige Zitronensaeure gelösten Phosphorsaure und Kalium einzugehen. Überblicht man die folgenden Zahlen, so erkennt man, dass der Boden trotz ihres höheren Gehalts an Phosphorsaeurereserve an diesem Naehrstoff bedürftig ist.

ZITRONENSAEURELÖSLICHE PHOSPHORSAEURE UND KALIUM NACH LEMMERMANN-FRESENIUS UND ZWAR IN MILLIGRAMMEN JE 100 G. TROKENBODEN

	Probe 1	*Prob 2*	*Durchschnitt*
P_2O_5	7,23	8,07	7,65
K_2O	14,63	15,37	15,00

Aus diesen Zahlen ist ersichtlich, dass die Menge der leicht löslichen P_2O_5 im Durchschnitt nur 7,5 mg. pro 100 g. Boden betraegt. Nach Lemmermann (1932) besitzt ein Boden weniger als 20 mg. P_2O_5 in 100 g. Boden, so ist es zu vermuten, dass eine Düngung mit Phosphorsaeure in den meisten Faellen zweckmaessig sein dürfte.

Der Durchschnittswert des in 1-prozentiger Zitronensaure löslichen Kalium weist 15 mg. je 100 g. Boden auf. Diese Menge stimmt mit der von Lemmermann (1932) angegebenen Grenzzahl überein, denn eine Kalidüngung dieses Bodens erscheint nicht als löhnend.

Wenn der weisse Boden im Berge Maquiling auch nicht als Traeger einer Vegetation dienen kann, da er sehr schwer ist, denn er stellte den Ackergeraeten ebenso dem Eindringen der Pflanzenwurzel einen grossen Wiederstand entgegen, doch könnte er zur Herstellung eines künstlichen Bodens benutzt werden können.

ZUSAMMENFASSUNG

Die Einzelergebnisse vorliegender Arbeit sind daher folgende:

1. Der weisse Boden im Berge Maquiling ist als fast rein Ton mit geringen Spuren von Titan, Eisen, Erdalkalien, Alkalien, Phosphor und Schwefel anzusprechen.

2. Ihr Salzsaeureauszug enthaelt alle Naehrstoffe. Stickstoff und organische Substanz sind nicht zugegen.

3. Der Gehalt an leicht lösliches Kalium liegt innerhalb der Grenzzhal. Bei der Phosphorsaeuregehalt ist er als bedürftig anzusehen.

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TABELLE 1

Physikalische Beschaffenheit des weissen Bodens

IN PROZENTEN	PROBE 1	PROBE 2	DURCHSCHNITT
Ton unter 0,002 mm	51,50	49,00	50,25
Feiner Schluff 0,002–0,006 mm	43,25	45,85	44,55
Grober Schluff 0,006–0,02 mm	0,60	0,54	0,57
Mehlsand 0,02–0,06 mm	1,00	1,40	1,20
Feinsand 0,06–0,2 mm	1,05	1,14	1,10
Sand 0,2–2 mm	2,18	2,02	2.10
Wasserkapazitat	65,47	66,43	65,95
Hygroskopizitat	26,00	24,00	25,00
Kolloidegehalt	96,42	95,57	96,00

TABELLE 2

Chemische Zusammensetzung auf Grund der Bauschanalyse

IN PROZENTEN	PROBE 1	PROBE 2	DURCHSCHNITT
SiO_2	45,20	46,68	45,94
TiO_2	0,10	0,20	0,15
Al_2O_3	39,65	38,05	38,85
Fe_2O_3	1,80	1,65	1,73
CaO	1,25	1,50	1,36
MgO	1,19	0,86	1,03
K_2O	0,20	0,31	0,26
Na_2O	0,32	0,26	0,29
P_2O_5	0,14	0,16	0,15
SO_3	0,77	0.60	0,69
Glühverlust	7,98	8,00	7,99

TABELLE 3

Nahrstoffvorrat auf Grund der 10 prozentigen Salzsaureauszüge

IN PROZENTEN	PROBE 1	PROBE 2	DURCHSCHNITT
SiO_2	0,13	0,17	0,15
TiO_2	0,01	0,01	0,01
Al_2O_3	2,63	3,00	2,82
Fe_2O_3	0,44	0,50	0,47
CaO	0,51	0,43	0,47
MgO	0,34	0,30	0,32
K_2O	0,09	0,12	0,11
Na_2O	0,06	0,08	0,07
P_2O_5	0,14	0,17	0,16
SO_3	0,72	0,60	0,66
N	0,00	0,00	0,00
Org. Subst.	0,00	0,00	0,00
Glühverlust	7,98	8,00	7,99
Unlöslich in HCl	85,78	86,12	85,95

COLLEGE AND ALUMNI NOTES

Prof. Bailey Willis, of Stanford University, who had been engaged by the Philippine government to study the geology of the Islands, was a campus visitor on June 23, as guest of the School of Forestry. At a convocation in the College of Agriculture auditorium, he gave an address on forests, rocks, and Nature in general.

According to a news item in *Science*, Dr. Sam F. Trelease, formerly a professor of botany in this College and at one time editor of the *The Philippine Agriculturist*, has become Torrey professor of botany at Columbia University.

The Los Baños Biological Club held its first meeting of the academic year on June 24, when the following papers were read:

Dr. G. O. Ocfemia. The abacá-disease situation in Davao.
Dr. Felipe M. Salvoza. The dipterocarps in Pañgil, Laguna.
Dr. Miguel Manresa. The influence of temperature upon European breeds of dairy cattle in India.

Dr. Manuel L. Roxas, '11, professor of agricultural chemistry emeritus, of this College, has recently been appointed chief of the technical staff and personnel of the National Development Company. Dr. Vicente C. Aldaba, '15, and Mr. Hilarion Henares, both former faculty members of this College, have joined Doctor Roxas on the staff of that company, as industrial technologist and industrial engineer, respectively.

Mr. Crispin Las Marias, '36, who is a holder of the certificate in agricultural education, was recently appointed teacher in Batac Rural High School.

Assistant Professor Alejandro B. Catambay, '24, of the Department of Agricultural Engineering, was recently commissioned first lieutenant, Infantry, in the Philippine Army Reserve. Receiving similar commissions at the same time were Primo R. Carreon, '25, and Hermenegildo R. Rosales, '27, both of whom are chemists in the Central Azucarera Don Pedro, Nasugbu, Batangas.

RESEARCH IN THE UNIVERSITY OF THE PHILIPPINES [1]

The report of President Jorge Bocobo, of the University of the Philippines, for the academic year June 1, 1935, to May 31, 1936, which recently came to hand, contains one striking feature on the subject of research. Out of a total of 583 pending scientific investigations in the entire University for the period under review, 283 were conducted in the College of Agriculture. These figures mean for this College approximately 40 per cent of the University's total.

It seems scarcely a matter to be proud of that this College should shine at the expense of its colleagues, particularly because the college that showed the second largest number had to its credit only 88 pending researches, or 15 per cent of the University's total. The point is not that "victory is more glorious to the victor, the greater the might of the vanquished," as Boccaccio wrote over five centuries ago. In the College of Agriculture, there are some seventy faculty members, including assistants, not all of whom are researchers, as may be readily judged by the nature of their appointments. This number represents less than 14 per cent of the University's faculty roster of about 500. False modesty aside, it is a temptation to draw implications which would be flattering to our self-esteem. Not only would it be ungracious to do so, however, but such an attitude of mind can serve merely to distort perspectives.

In the University, one of the greatest drawbacks to research is the existing requirement of a minimum teaching load of fifteen hours a week for each faculty member, exclusive of the time used in preparation of lectures and class material, correction of examination papers and notebooks, and related work which consume a surprisingly large part of the working day. In addition, the extra demands on time and energy by various University or college committee memberships and other essential extracurricular duties have a way of filling up the program of activity. In the College of Agriculture, these various calls for service are just as keenly felt as in the other units of the University; perhaps more so, because of the self-contained nature of this community, owing to distance from the administrative center in Manila. There are cases where some of the facul-

[1] General contribution from the College of Agriculture No. 565.

ty members have not the time to read and keep abreast in their respective lines of specialization. In spite of themselves, therefore, they are constantly threatened with the menace that Capt. Liddell Hart vividly portrays in the following passage in *The Ghost of Napoleon*: "It was Wolfe at Louisburg who, when one of his officers remarked that the way he was using his Light Infantry recalled the tactics of the καρδουχοι candidly replied: 'I had it from Xenophon, but our friends here are astonished at what I have done because they have read nothing.'" As if further to try the researcher's patience, the uncertain fate of requisitions for equipment and supplies that are essential for the proper prosecution of experimental work makes frequent call for the exercise of the three old-fashioned virtues. At times, lonely minor parts of an apparatus are sent reluctantly, leaving the dismembered main body to be safely forgotten on the other side of the Pacific Ocean. More often, there is not even this gladdening sign of partial, albeit ineffectual, wish-fulfillment. If absence makes the heart grow fonder, then we have not been wanting in opportunity to develop and nurture an undying love for scientific instruments.

The number of scientific projects credited to the College of Agriculture looms large alongside that of the other colleges; but it shrinks to relative insignificance when viewed against the background of the enormous unexplored field of scientific agriculture in the Philippines. It, likewise, suffers by comparison with institutions of a similar kind abroad. That some research can be carried on in this College is in part ascribable to its fortunate location in the midst of an abundance of interesting material where a man with the necessary training and inclination has his scientific curiosity inevitably aroused. Also, he lives in an atmosphere where, we might say, "the gods approve the depth and not the tumult of the soul." Moreover. the requirement in our basic curricula that each candidate for a bachelor's degree present a graduation thesis has contributed some 40 per cent to the total number for the College.

That the research projects in question are not merely nominal is attested by the sustained flow of articles in *The Philippine Agriculturist*, as well as by the fact that this journal, which is almost exclusively dependent for its supply of copy on local production, can continue to observe strict punctuality in date of issue. Since the data on which President Bocobo based his report were submitted, over 25 per cent of the projects cited therein have already appeared in print. The remaining titles in the list are mostly those of long-

range investigations, which require several years for satisfactory results.

After the work of observation and experimentation is concluded, the researcher's grinding task of systematically arranging the results and making these take the shape of an article for publication is not generally appreciated. José Rizal, the foremost Filipino patriot, writing to Father Vicente Garcia in 1891, complained: "During the three centuries of Spanish influence, the Filipinos, in my judgment, did not advance as they should have. This was due to our talented men having died without leaving anything beside the renown of their names. They did not leave in writing the fruits of their experience. We have had our share of great geniuses. . . . These men studied, learned, and discovered a great deal, but it all died with them. It ended because they left no writings. So in our study of Philippine life, we have to begin again at the very beginning." Were a Rizal writing to a Father Garcia four decades later, his criticisms would, of course, be somewhat mollified. We lay no claim to geniuses and talented men in the College of Agriculture. But surely we have not been entirely amiss in our duty to leave our observations in writing.

LEOPOLDO B. UICHANCO

Photograph by A. P. Varona

The Philippines' smallest complete sugar central, for students' laboratory practice at the College of Agriculture

STABILIZING OUR CO-OPERATIVE MARKETING ASSOCIATIONS [1]

PABLO N. MABBUN
Of the Department of Agricultural Economics

Agricultural co-operation is a striking development in the rural life of the present century. It offers to the inherently decentralized industry of agriculture a workable, explainable scheme of organization designed to set up an agency for the progressive study and adjustment of the larger problems which are being forced upon the industry by the inescapable process of our economic evolution.[2] In fact, most countries today owe the progressive state of their agriculture and rural life to the achievements of this new development in the business of agriculture.

The achievements of co-operative marketing in the Philippines, however, have not been very encouraging. This has given rise to suggestions for improving our co-operative marketing associations. A suggestion has come from certain quarters that federating the existing associations will improve the business of co-operation among our farmers. But the business of inefficient co-operative marketing associations cannot be improved by merely consolidating them. On the contrary, this method might only magnify the inefficiency of the whole movement. What is needed, before any attempt at consolidation is undertaken, is to study the causes of failure of the associations and then reorganize them in accordance with remedies that might be discovered feasible to stabilize their businesses.

The purpose of this paper is to present the primary causes of the failure of certain co-operative marketing associations whose organization and business operations have been studied in recent years by the Department of Agricultural Economics. Remedies will also be suggested which, if applied to the further promotion of the movement, may stabilize future co-operative marketing associations and place the existing inefficient ones on a sounder business footing.

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[1] General contribution from the College of Agriculture No. 566.

[2] Eliot G. Mears and Mathew O. Tobriner, 1926, *Principles and Practices of Co-operative Marketing*, Ginn and Co., New York, p. V. See also E. G. Nourse, "Economic Philosophy of Co-operation," *American Economic Review*, Vol. 12, 1922, p. 281.

GOVERNMENT ENCOURAGEMENT

Since 1927 the Philippine Government has expressed its approval of the development of co-operative marketing among our farmers by enforcing the Co-operative Marketing Law (Act No. 3425) and designating the Bureau of Commerce to take charge of the promotion of the movement. Since the Co-operative Marketing Law went into effect, various other laws were passed by the local legislature tending to give further government encouragement to the movement. Among these laws are: the Bonded Warehouse Act (Act No. 3893), of November 16, 1931,[5] which requires owners of warehouses to secure licenses from the Director of Commerce before they can receive rice or palay for deposit in their *bodegas* but exempts co-operative marketing associations from such requirement; Act No. 3929, of November 28, 1932, authorizing the construction of warehouses by municipalities in which agricultural products may be deposited; Act No. 3932, of November 29, 1932, authorizing the expenditure of ₱2,000,000 for the construction of permanent bridges and warehouses; Commonwealth Act No. 95, of October 27, 1936, authorizing the Philippine National Bank, the National Development Company, and the Secretary of Agriculture and Commerce to establish and maintain warehouses for tobacco and other marketable products; Commonwealth Act No. 116, of November 5, 1936, making available the Rice and Corn Fund not only to co-operative credit associations but also to co-operative marketing associations; and Commonwealth Act No. 192, of November 14, 1936, authorizing the establishment of a public corporation to be known as the National Produce Exchange. One of the functions of this exchange is "to encourage the establishment of co-operative marketing associations preparatory to the opening of produce exchanges in the locality served by these associations." [4]

The Philippine National Bank, a government institution, also extends loans to the co-operative marketing associations, granting them loans as much as 70 per cent of the market value of the products they handle.

It is evident, therefore, that the Philippine Government desires to see the permanent establishment of co-operative marketing as a force in the advancement of agriculture and rural life in this country.

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[3] This law repealed Act No. 3469, the first Bonded Warehouse Act passed by the Philippine Legislature in 1927.

[4] *Commonwealth Act No. 192*, section 2, sub-section 2.

PROGRESS OF CO-OPERATIVE MARKETING

In 1924 only two co-operative marketing associations were in operation. Both of these associations were organized under the direction of the Field Agent of the Bureau of Commerce among the tobacco growers in the Cagayan Valley. The Tuguegarao Tobacco Growers' Association, Inc. sold 5,576.63 quintals of tobacco valued at ₱64,302, or an average price of ₱11.33 per quintal, in 1925, its first year of operation. In 1926 the sales of this association increased to 7,413.56 quintals but because of low prices this tobacco was valued at only ₱56,783.26, or an average price of ₱7.66 per quintal. Non-members in the locality received for their tobacco ₱8 per quintal in 1925, and from ₱6 to ₱9 per quintal in 1926. The membership of this association increased from 450 in 1925 to 2,029 in 1926.[5]

The Ilagan Tobacco Growers' Association, Inc., sold only 232 quintals of tobacco at prices ranging from ₱14 to ₱15 per quintal in 1926. Non-members in the locality sold their tobacco for ₱8 to ₱12 per quintal in that year. This association had a membership of 201 in 1925 and 322 in 1926.[6]

After two years of operation, however, these two associations became practically inactive, owing to lack of steady member support.

When the Co-operative Marketing Law (Act No. 3425) went into effect, in 1927, associations among producers of various agricultural products were organized. At the close of 1932 there were incorporated with the Bureau of Commerce eighty co-operative marketing associations handling tobacco, rice, sugar, copra, abaca and nipa vinegar. Only forty-six of these associations, however, were in active business. The aggregate volume of business handled by these active associations amounted to ₱2,581,000, distributed according to quantity of products as follows:[7]

Total number of active association in 1932		46
Total product handled:		
Palay or cleaned rice, cavans	405,000	
Sugar, kilos	315,000	

[5] *See* Pablo N. Mabbun. 1927. Study of the Tobacco Growers' Association, Inc., of Tuguegarao, Cagayan. The Philippine Agriculturist 16: 19–33; *also* Progress of tobacco co-operative marketing in Cagayan, by the same author, The Philippine Agriculturist 16: 341–350.

[6] *See* Pablo N. Mabbun. 1927. Progress of Tobacco Co-operative Marketing in Cagayan. The Philippine Agriculturist 16: 341–350.

[7] From Reports of the field service of the Bureau of Commerce. Figures for 1932 are quoted in Dimas Maulit, *Introduction to Agricultural Economics in the Philippines*, Bureau of Printing, Manila, 1936, p. 233.

Abacá, kilos	52,000
Copra, kilos	11,000
Tobacco, quintals	13,000
Nipa vinegar, liters	1,000,000
Total value of all the above products	₱2,581,000

At the close of 1935 there were one hundred and five associations incorporated with the Bureau of Commerce, but only forty-five of these were in active business. Of the forty-five active associations, twelve were organized among rice growers mostly in Nueva Ecija and thirteen were tobacco associations, mostly in the province of Isabela. With this information as a guide the organization and business operations of the co-operative marketing associations in Isabela were studied in 1935 and 1936. Certain associations in Nueva Ecija were also studied during the same period. Results of these studies are discussed below.

ANALYSIS OF CERTAIN ASSOCIATIONS

Nineteen co-operative marketing associations have been organized in the province of Isabela, but only twelve of these were in operation at the close of 1935, the remaining seven having discontinued their business activities. (See table 1). The twelve active associations sold 13,990.0 quintals of tobacco, valued at ₱83,628.04, or at an average price of ₱5.97 per quintal, in 1932. Non-members in the province sold their tobacco at a maximum price of ₱4 per quintal. (See table 2). These associations, however, discontinued selling the product of their members co-operatively, after they had disposed of all of the 1932 crop, owing either to lack of continuous member support, to inadequacy of volume of business to permit economical operations in competition with private marketing agencies, or to inefficiency of management.[8]

A similar situation was found to exist among the co-operative marketing associations in Nueva Ecija. Of the seventeen associations organized in that province, eight were in active operation up to the close of 1935, two were converted into bonded warehouses, three never started business operations, and four closed down either owing to misappropriation by the manager or to lack of sufficient volume of business. (See table 3). It is interesting to note that even the most successful among the eight active associations had only 144 out

[8] See Concordio C. Mandac, Analysis of the organization and business operations of the co-operative marketing associations in the province of Isabela. Thesis presented for graduation with the degree of Bachelor of Agriculture from the College of Agriculture, University of the Philippines, 1936. Unpublished.

of its 310 members who were actively supporting their organization. The rest neither delivered their rice nor paid their dues to the association. This particular association sold palay and rice valued at ₱107,340.42 in 1934. (See table 4).[9]

While the records of the business transactions of the above associations indicate possibilities of co-operative business among our farmers, nevertheless, the nature of their organization suggests room for stabilizing the co-operative movement.

STABILIZING CO-OPERATIVE MARKETING

It has been found that the failure of certain co-operative marketing associations among the tobacco and rice growers has been due to: (1) lack of continuous member support, (2) inadequate volume of business to permit economical operation in competition with existing private marketing agencies, and (3) inefficiency or dishonesty of management. The existence of these three causes of failure of co-operative marketing can be explained by the fact that our farmers have been organized into co-operative associations without having felt a legitimate, impelling need for co-operation. The farmers have depended almost wholly upon the leadership and initiative of the government in the promotion of this movement. Consequently, if this leadership and initiative did not come, the farmers were helpless in studying and solving their own problems.

The remedy is, therefore, to develop leadership and initiative among our farmers by modifying the procedure heretofore followed in organizing them into co-operative marketing associations. Give them a chance to develop their own leaders and to study and solve their own problems. The following procedure is suggested as a guide for the organization of future co-operative marketing associations and for reorganizing existing inefficient ones.

I. Survey preliminary to organization. The first essential of the co-operative marketing association is the need for the association. This means that in a given area some definite economic function not now being performed by existing agencies could be accomplished by a co-operative marketing association; or that an economic activity now carried on by existing agencies could be more efficiently achieved through co-operation. This need should be one that is likely to continue over a period of years, rather than one of a temporary nature. It can, however, be determined only after a thorough study of the conditions in the prospective area to be served by the association.

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[9] Figures were obtained from the annual reports of the association on file at the Department of Agricultural Economics.

The first step in making this survey is to call a general meeting of all the farmers in the proposed area to determine how many of them are interested in the proposed association. At this meeting, the promoter [10] should advise with the farmers as to the advisability of organizing a co-operative marketing association. He should present to the farmers available information as to the possibilities of success or failure of the proposed co-operative. This presentation should be followed by a free and frank discussion by the farmers themselves. After all phases of the project have been presented and fully discussed, a vote should be taken to determine how many of those present feel that they are determined to support the proposed association.[11] Then, a committee of from five to ten of the most intelligent and earnest among the willing farmers should be appointed by the promoter to make a thorough survey of the farmers and conditions in the proposed area.

The details of this survey will, of course, differ for each commodity, as well as for each area studied. However, the following points will secure the information needed to develop sound thinking among the prospective leaders and members as well as provide the basis for determining the type of organization most likely to succeed under the known conditions.[12]

A. HISTORY OF PAST AND PRESENT CO-OPERATIVE EFFORT IN THE PROPOSED AREA. The following information should be secured under this point:

1. How many co-operatives now operate in the area?
2. How long has each been in business?
3. Do farmers feel these associations have been successful? Why do they feel as they do?
4. If associations have failed, why?
5. What services have been rendered by past or present co-operatives?
6. Compare the per unit cost of handling the product through the co-operatives with other agencies.
7. What percentage of farmers in the area now utilize the services of the co-operatives?

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[10] The promoter is invariably a field agent of the Bureau of Commerce.

[11] The usual procedure is to make the farmers sign the marketing contract at this stage of the organization activity. This has resulted in most cases in dampening the enthusiasm of the members soon after their association has started business operations, because the farmers have not fully understood the problems facing their association.

[12] See B. B. Derrick, "Education preliminary to co-operative organization," an address delivered at the Farm Economic Association Meeting at Cincinnati, Ohio, December 28–30, 1932. (Mimeographed).

B. GENERAL SURVEY OF THE AREA. The following information should be secured under this:

1. Area of the region that can profitably be included.
2. Volume of each of chief products marketed.
3. Types of farmers, e. g., tenants or owners; area of farms of each; intelligence and community interest of each.
4. Transportation advantages or disadvantages of available locations.
5. How competing areas affect prices in the proposed area.
6. Any substitute products competing from the standpoint of alternate use.
7. Types of price-making forces, e. g., middlemen and types of, produce exchanges, etc. Whether these factors are controlled within or outside of the proposed area.
8. Whether prospective members are financially able and mentally inclined to become supporting members of a co-operative marketing association.

C. EXISTING MARKETING AGENCIES. Facts to be known on this point are:

1. Estimated volume of business handled by each.
2. Can their facilities, such as buildings, warehouses, etc. be leased or purchased?
3. Their methods of operation, such as:
    - (a) Services now rendered by each
        - (1) Per unit cost of such services
        - (2) Methods of assembling products handled
    - (b) Basis, time, and reliability of payment for products handled.
4. Accessibility of their plants and facilities for probable membership in the proposed association.
5. Causes of dissatisfaction with existing marketing agencies, if any.
6. Can a co-operative improve existing services? How?
7. Advantages and disadvantages of the proposed area from the production and marketing standpoints.
8. Characteristics of the product to be marketed that make it especially adapted to co-operative handling: Does it lend itself to standardization as to quality, market grades, and uniform packaging or baling?
9. Disposition of the marketable surplus of the product in the proposed area and method of payment for it.
    - (a) Quantity to be disposed of locally?
    - (b) Quantity to be sold to other markets?
    - (c) Quantity to be manufactured?

D. MARKETING FACILITIES. Information on the following should be secured:

1. Transportation to assembling points, e. g., carts, sledges, or other vehicles driven by animal power, trucks, automobiles, railroad, or water.
2. Transportation to markets.
3. Sources of finances, e. g., private or governmental. Are they adequate?
4. What kind of facilities are needed by the proposed association? Warehouses? Other buildings? Give estimated costs.
5. Can facilities be leased? Cost and capacity of available space. Do existing buildings have adequate transportation service?
6. Kind of power available, e. g., electric, steam, or water.

E. TYPE OF CO-OPERATIVE ASSOCIATION NEEDED IN THE AREA. Federated vs. centralized type. Mabbun (1935) pointed out advantages of the federated type for our tobacco farmers.[13]

1. With capital stock or non-stock? If with capital stock, estimate amount of fixed capital, operating capital, and name possible methods of securing necessary funds, e. g., by mortgage, sale of bonds, common or preferred stock, etc. Determine how each can be issued legally.
2. Provide for affiliation with larger associations should conditions justify.
3. Study legal requirements.

F. ASSOCIATION OPERATION. Study probable needs of the proposed association in respect to its business activities.

1. Prepare a detailed operating budget.
2. Estimate detailed budget of fixed costs beyond the control of the association.
3. Estimate anticipated volume of business.
4. Give classification of quality and market grades of products as they are now produced in the proposed area.
5. Are producers of the permanent or shifting type?
6. Estimate prospective volume necessary to pay above operating costs and to establish a reserve fund.
7. Compare (6) and (4) to determine the possible financial success of the association.

G. POSSIBLE BENEFIT OF A CO-OPERATIVE ASSOCIATION IN THE PROPOSED AREA.

1. Name probable advantages of a co-operative association in the proposed area.
2. Name probable disadvantages of the same.
3. Draw conclusion as conservatively as possible from the result of the survey.

After the foregoing information has been secured and analyzed by the economists of the Bureau of Commerce or other qualified persons, it should be taken by the committee and the field agent of the Bureau of Commerce to small group meetings of not more than fifty prospective members. The major findings should be carefully discussed at these meetings so as to give the prospective members a complete picture of the marketing problems facing them. If a sufficient volume of business for economical operation is available and in competition with existing agencies, the prospective leaders and members should go ahead with the organization of the association.

II. Choice of membership. The next step in the development of the co-operative association is the selection of its membership. No producer should be invited to join a co-operative marketing associa-

[13] See Pablo N. Mabbun. 1935. Co-operative marketing and our tobacco farmers. The Philippine Agriculturist 24: 451–463.

tion who lacks the mental inclination to produce and deliver to the association a product capable of meeting specific market demands. The member meeting this requirement will in all probability continue to acquaint himself with the current market problems of his association. For this reason he will be a continuous booster for it rather than continue to blame his organization for conditions of which it has little or no knowledge.

When enough farmers have signed an agreement to produce the required volume of business for economical operation, then a meeting of these signers of the marketing contract should be called to elect the officers of the association. After this, the officers can proceed to the incorporation of the association.

III. Incorporation. Incorporation gives the association a legal standing. According to the Co-operative Marketing Law (Act No. 3425), at least fifteen members may adopt the articles of incorporation and by-laws and then file these with the Bureau of Commerce. Forms for the articles of incorporation and the by-laws of co-operative marketing associations are invariably prepared and furnished by the Bureau of Commerce. The articles of incorporation must set forth the following:

1. The corporate name of the association in which the word "co-operative" must be included.
2. The purpose or purposes for which the association is formed and the agricultural product or products to be handled by it.
3. The place or places where the association's principal business will be transacted, and the place where its principal office will be located in the Philippines.
4. The number of years which the association is to exist, which should not be more than 50 years.
5. The names and addresses of the incorporators.
6. The names and addresses of the incorporating directors, the number of which should not be less than five.
7. If organized without capital stock, the general rule or rules applicable to all members by which the property rights and interests of each may be determined or fixed, and provision for the admission of new members.
8. If organized with capital stock, the following are required: the amount of such stock, the number of shares into which it is divided and the par value of each share, the amount of capital stock subscribed and the sum paid up by each subscriber. The capital stock may be divided into common and preferred stocks. If so divided, a statement of the number of shares of stock to which preference is granted, the nature and definite extent of the preference and privileges granted to holders, and the manner of redeeming or

retiring such shares of preferred stock should be given. At least 20 per cent of the entire capital stock must have been subscribed and at least 20 per cent of the subscribed shares must have been paid at the filing of the incorporation papers.

The by-laws may provide for any or all of the following matters:

1. The time, place, and manner of calling and conducting the meetings of the association.
2. The number of members or stockholders entitled to vote, constituting a quorum.
3. The right of voting members or stockholders to vote by proxy or by mail and the conditions, manner, form and effects of such votes.
4. The number of directors constituting a quorum.
5. The qualifications, compensations, duties and terms of office of directors and officers, time of their election, and the mode and manner of giving notice thereof.
6. Penalties for violations of the by-laws.
7. The amount of entrance, organization and membership fees, if any, the manner and method of collection of such fees, and the purposes for which they may be used.
8. The amount which each member shall be required to pay annually or from time to time, if at all, to carry on the business of the association. The charge, if any, to be paid by each member for services rendered by the association to him and the time of payment and manner of collection of such charges. The marketing contract between the association and its members which every member may be required to sign.
9. The qualifications of members of the association and the conditions precedent to membership or ownership of common stock; the method, manner, and time permitting members to withdraw or the holders of common stock to transfer their shares; the manner of assignment and transfer of interests of members and the shares of common stock; the conditions upon which and time when membership in the association expires; the mode, manner, and effect of the expulsion of a member; the manner of determining the value of a member's interests and provision for their purchase by the association upon his death, withdrawal, or expulsion, or at the option of the association, upon the purchase of his interests at a price fixed by conclusive appraisal by the board of directors.

Amendments to the articles of incorporation must first be approved by the majority of the members of the board of directors and then adopted by a vote of the majority of the voting members of the association before such amendments are filed with the Director of Commerce. Amendments to the by-laws or repeal of old by-laws must be approved by a vote of the majority of all the voting members of the association before such amendments or new by-laws are filed with the Director of Commerce.

When the incorporation papers are filed, they should be accompanied by a fee of ₱15.00. An additional fee of ₱5.00 is required upon filing of amendments to the incorporation papers.

IV. Choice of the manager of the association. The final step, but not the least important activity, in the development of the association is the choice of its manager. This responsibility is left to the board of directors. In choosing the manager care should be taken that, within the financial reach of the association, the most efficient man available, whose ability is adequate to handle the volume of business and the membership of the organization, is hired. A man who has had a number of years of successful experience in the same line of business to be handled by the association should be preferred. A man who may be neither "too big" nor "too small" for the business affairs and membership of the association should be the most desirable.

Under the proper leadership, the members enter into their organization activities free of prejudice and with a complete understanding of the problems facing their associations. The foregoing procedure, while requiring more time to get the association started, offers no excuse for extravagant promises of organizers. Moreover, it gives an opportunity for our farmers to develop their own leadership and initiative, thus enabling them to study and solve their own problems. With leadership and initiative developed among our farmers they will eventually cease to expect the government to do everything for them as they have heretofore been inclined to do. They will then seek the advice of the state only when they are ready for its counsel. And last, but not least, associations organized under the above procedure will in all probability have better chances of success because they will be founded upon principles usually followed by all other forms of business organization.

TABLE 1

Showing status of co-operative marketing associations in the province of Isabela, 1936

NAME OF ASSOCIATION	DATE OF INCORPORATION	NUMBER OF MEMBERS	PRESENT STATUS, 1936
Echague Tobacco Growers' Co-operative Marketing Association ...	Jan. 8, 1929	—	Not in operation, malversation of funds
Añgadanan Tobacco Growers' Co-op. Marketing Association	Jan. 8, 1929	41	In operation
Cabagan Tobacco Growers' Co-op. Marketing Association	Feb. 12, 1929	—	Not in operation
Cauayan Tobacco Growers' Co-op. Marketing Association	May 9, 1929	—	Not in operation
Easter Añgadanan Tobacco Growers' Co-op. Marketing Association ...	June 17, 1929	134	In operation
Jones Tobacco Growers' Co-op. Marketing Association	June 17, 1929	—	Not in operation
Sta. Maria Tobacco Growers' Co-op. Marketing Association	June 17, 1929	473	In operation
Ilagan Tobacco Growers' Co-op. Marketing Association	July 10, 1929	97	In operation
Antatet Tobacco Growers' Co-op. Marketing Association	Sept. 24, 1932	99	In operation
Kalabaza Tobacco Growers' Co-op. Marketing Association	Sept. 24, 1932	54	In operation
Gamu Tobacco Growers' Co-op. Marketing Association	Oct. 3, 1932	118	In operation
Naguilian Tobacco Growers' Co-op. Marketing Association	Oct. 3, 1932	77	In operation
San Pablo Tobacco Growers' Co-op. Marketing Association	Jan. 22, 1932	82	In operation
Reina Mercedes Tobacco Growers' Co-op. Marketing Association ...	Oct. 3, 1932	78	In operation
Magat Tobacco Growers' Co-op. Marketing Association	......, 1932	—	Not in operation
Minañga Tobacco Growers' Co-op. Marketing Association	Mar. 13, 1933	91	In operation
Tumawini Tobacco Growers' Co-op. Marketing Association	Dec. 2, 1933	—	Not in operation
Cabatuan Tobacco Growers' Co-op. Marketing Association	Feb. 14, 1933	87	In operation
Sto. Tomas Tobacco Growers' Co-op. Marketing Association	......, 1929	34	In operation
Total number of associations ..	19		

TABLE 2

Showing volume of sales of 12 tobacco co-operative marketing associations in the province of Isabela, 1932

NAME OF TOBACCO GROWERS' CO-OP. MARKETING ASSOCIATIONS	TOTAL PRODUCT SOLD THROUGH THE BUREAU OF COMMERCE, 1932	TOTAL VALUE OF TOBACCO SOLD, 1932	TOTAL EXPENSES OF MARKETING	NET RECEIPTS FOR TOBACCO SOLD IN 1932
	quintals	*pesos*	*pesos*	*pesos*
Sta. Maria	1,158.0	5,816.26	1,694.91	4,121.35
Gamu	772.5	4,013.88	1,459.11	2,554.77
Añgadanan	720.0	3,601.26	1,216.90	2,384.36
Naguilian	1,392.5	6,593.13	2,741.50	3,851.63
San Pablo	175.0	1,108.50	270.34	838.16
Cabagan	650.0	3,350.38	1,030.46	2,319.92
Kalabaza	1,297.5	8,309.14	2,533.04	5,776.10
Reina Mercedes	830.0	7,006.38	2,171.50	4,834.88
Antatet	2,640.0	14,741.65	5,065.98	9,675.67
Cabatuan	3,717.5	25,710.79	5,983.80	19,526.99
Minañga	325.0	1,771.60	612.94	1,158.66
Eastern Añgadanan	312.0	1,605.07	672.01	933.06
Total (12 assn.)	13,990.0	83,628.04	25,452.49	57,975.55
Average		5.97	1.81	4.14

TABLE 3

Showing status of co-operative marketing associations in Nueva Ecija, 1935 [a]

NAME OF ASSOCIATION	LOCATION AND DATE OF ORGANIZATION	CAPITAL AUTHORIZED	PRESENT STATUS (1935)
		pesos	
Homesteaders' Co-operative Marketing Assn.	Cabanatuan 1927	20,000	Converted into bonded warehouse
Cabanatuan Co-operative Marketing Association	Cabanatuan 1929	150,000	Now a bonded warehouse
Samahang Magbubukid Co-op. Marketing Assn.	Cabanatuan 1929	150,000	In operation
Lapuz Co-operative Marketing Association	Cabanatuan 1929	150,000	Never opened business
Vi-ver-ven Co-operative Marketing Association	Cabanatuan 1929	100,000	Never opened business
Baluarte Co-operative Marketing Association	Baluarte, Gapan, 1929	100,000	Closed
Gapan Co-operative Marketing Association	Gapan, 1929	100,000	Closed, misappropriation
Pajo Co-operative Marketing Association	Gapan, 1929	Non-stock	In operation
Santiago Co-operative Marketing Association	Gapan, 1929	Non-stock	In operation
San Lorenzo Co-operative Marketing Assn.	Gapan, 1932	Non-stock	Closed by Manager
Guimba Co-operative Marketing Association	Guimba, 1930	20,000	In operation
Jaen Co-operative Marketing Association	Jaen, 1929	125.000	In operation
Peñaranda Co-operative Marketing Association	Peñaranda 1930	25,000	In operation
San Jose Co-operative Marketing Association	San Jose, 1930	5,000	Never opened business
Liquetado Co-operative Marketing Association	Santo Domingo 1930	Non-stock	In operation (successful)
San Isidro Co-operative Marketing Association	San Isidro 1930	Non-stock	In operation
San Nicolas Co-operative Marketing Association	San Nicolas, Gapan, 1929	100,000	Closed by Manager
Total number of associations	17	———	———

[a] Data furnished by the Bureau of Commerce.

TABLE 4

Liquetado Co-operative Marketing Association
Report on Operations

	1933		*1934*	
Rice sales	₱92,590.14		₱107,340.42	
Palay sales	11,270.36		4,703.30	
Tiki-tiki	1,546.51		2,348.52	
Binlid sales	180.51		388.53	
Mata-mata sales	54.88	105,642.40	27.20	114,807.97
Less cost of goods sold:				
Cost of rice			89,886.89	
Cost of palay			3,316.51	
Production expenses			5,764.84	
Space cost		89,347.37	1,691.16	100,659.40
Gross trading profit		16,295.03		14,148.57
Other income:				
Revenue from milling	72.96		55.46	
Revenue from shrinkage	20.73		15.57	
Revenue from shortage	43.06		38.37	
Insurance fees collected	1,017.80		1,186.18	
Fin. income-Int. earned	1,453.19		3,060.35	
Membership fees	71.00	2,678.75	122.00	4,477.93
Gross profit		₱18,973.74		₱18,626.50
Less general expenses:				
Administration expenses			3,333.59	
Selling expenses			10,445.05	
Financial Expenses-Int. paid			2,354.83	
Profit and loss		11,841.98	4.98	16,135.45
10% for Sec.-Manager and 5% for employees' salaries		587.20		
Net profit		6,544.59		2,488.05

Total number of members—310, but only 144 of them were active and 53 paid dues. The amount of membership fee paid by members is ₱2.00 and ₱1.00 annual dues, although the by-laws of the association gives these as ₱5.00 and ₱2.00 respectively.

Percentage of gross trading profit to sales

	1933	*1934*
Gross trading profit	₱ 16,295.03	₱ 14,145.57
Total sales	105,642.40	114,807.97
	15½%	12%

RECENT PHYSICAL CHANGES IN THE WATER OF LAGUNA DE BAY AND THEIR EFFECT ON THE LAKE FAUNA [1]

S. M. CENDAÑA AND A. M. MANE
Of the Department of Entomology

WITH ONE MAP AND ONE CHART

Laguna de Bay, in the southern part of the island of Luzon, is a shallow [2], fresh-water lake [3]. It is the largest lake in the Philippines, its area being approximately 346 statute miles. It communicates with the sea by the short Pasig River, which meanders along the flat lands between the lake and Manila Bay.

With few exceptions, the fauna of the lake consists of strictly fresh-water resident forms. Even the "tagan", *Pristis microdon* Latham, which is a member of the shark family and is of typically marine affinity, has become adjusted to an exclusively fresh-water habitat.

The level of the lake is only about a meter above that of Manila Bay. This elevation varies according to the season of the year, being highest during the height of the rainy season, and lowest during May and June. Because of the relatively small difference between the level of the lake and that of Manila Bay, there have been speculations on the possibility of sea water entering the lake. No actual observations on sea water actually entering the lake has so far been recorded, however. The present work was undertaken to collect field data pertinent to this subject.

METHODS

The observations herein reported were obtained in connection with another series of studies by the authors on the fluctuations in

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[1] Experiment Station contribution No. 1183. Received for publication June 29, 1937.

[2] Soundings made in the lake in 1900 (Becker, 1900) showed that the deepest part of the lake was about six meters to the west of Talim Island. The present authors, in the course of the present work, obtained the same depths in that neighborhood only during the height of the rainy season.

[3] According to Adams (1910), the concensus of opinion is that what is now Laguna de Bay was once an arm of the sea, very much like Manila Bay is today; but that as a result of one of the eruptic fits of Taal Volcano or the diastrophic movement of the land to the west, it has become separated from the sea, and has since become fresh water.

density of population of certain micro-arthropods in the lake during the period from March, 1935, to June, 1937. The method consisted chiefly in determining the chlorine content of the lake water, the changes in the water level of the lake, and observations on the more evident changes in the lake fauna. The base of operations for this work was the limnological station of the College of Agriculture at Mayondon, Los Baños, Laguna. The work, however, extended over various representative points in the lake.

Location of observation stations in Laguna de Bay

For purposes of the study, four observation stations were established in March, 1935: one off the shore of Mayondon; another about two kilometers off the shore of Barrio Malakaban, Talim Island; the third near Diablo Pass; and the fourth about three kilometers off the shore of Darañgan, Binañgonan, Rizal. These are shown in the map as stations 1, 3, 4 and 5, respectively. The chlorine content of water samples obtained monthly at each station at a depth of two meters below the surface of the water was determined. On June 27,

1936, when it was noticed that there was a considerable increase in the salinity of the water, the determinations were made weekly. Also, in order to understand more precisely the progress of salt-water invasion in the lake, additional stations were established, at which weekly determinations of chlorine content were likewise made. The stations added were as follows:

Established on June 29, 1936:

Station 2—Midway between Talim Island and Mayondon Point.

Station 11—Midway between Boñga Island and Llanos, Jalajala, Rizal.

Station 13—Midway between Barrio Naglabas, Jalajala, and Barrio Linga, Pila, Laguna.

Station 14—Midway between Barrio Bagumbong, Jalajala, and Santa Cruz, Laguna.

Established on July 6, 1936:

Station 8—At the mouth of Pasig River, towards Laguna de Bay.

Station 9—Midway between Diablo Pass and Tanay, Rizal.

Station 10—Midway between Barrio Boor, Talim Island, and Jalajala, Rizal.

Established on July 13, 1936:

Station 15—Midway between Barrio Matiquio, Jalajala, and the mouth of Pagsanjan River.

Established on July 20, 1936:

Station 6—Off Alabang shore, a third of the distance toward Binañgonan, Rizal.

Station 7—Off the shore of San Pedro, Laguna, a third of the distance toward Diablo Pass.

Stations 1, 2, 3, 4, 5, 6, 7, and 8 are on the west arm of the lake; stations 9, 10, and 11 are in the middle arm, while stations 12, 13, 14, and 15 are on the east arm of Laguna de Bay.

Readings on the levels of the lake water were made at weekly intervals. For this purpose, two reading stations were established, one at the limnological station of the College of Agriculture at Mayondon, and the other in the town of Los Baños [4]. The two stations are about a kilometer apart, and the readings were made at about the same time on the same day.

Because the motor boat that was being used went out of order on August 31, 1936, chlorine observations since then have been made at the first station only.

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[4] Mr. Enrique M. Bautista, of the Department of Agricultural Engineering, determined for us the altitude of our base point at Los Baños; the base point at the limnological station is referred to the one in Los Baños.

RESULTS AND DISCUSSION

The chlorine content of the lake

The monthly chlorine content of water samples from stations 1, 3, 4, and 5 from March, 1935, to May, 1936, is presented in table 1.

It will be seen in this table that the chlorine content of the lake is slightly higher during the months of April and May (the average during these months was about 0.0030 per cent) than during the other months of the period studied. This slight increase in salinity certainly cannot be the immediate result of an inflow of salt water from Manila Bay at the time, for, as will be seen presently, if this were the case, the salt increment would have been noticed to be localized at first, and then, later, more generalized. Our observations were that this slight increase was at once simultaneous and general in the lake. The probable explanation is that this increase in salinity is due to the effect of rapid evaporation and less volume of water from the feeding streams during the dry season, resulting in a greater concentration of the salt contents in the lake.

The weekly chlorine content of the lake water at the various stations from May 28 to August 31, 1936, is presented in table 2, wherein it will be seen that:

1. The chlorine content of the lake water on June 27, 1936, in the four stations (1, 3, 4, and 5) examined rose abruptly over that of May 28, 1936. Thus, from 0.003 per cent it went up to 0.0096 per cent in station 1, the increase in salt content being 2.2 times; from 0.0031 per cent to 0.0187 per cent in station 3, 5.03 times; from 0.0032 per cent to 0.0667 per cent in station 4, 19.84 times; and from 0.0032 per cent to 0.0922 per cent in station 5, 27.81 times. The sequence of the foregoing figures may be taken to mean that salt from some outside source must have recently invaded the lake, some time between May 28 and June 27, 1936, during the height of the dry season, when the water level of the lake was at its lowest.

2. Station 5, which showed the greatest increase in chlorine content on June 27 was the one nearest the Pasig River, which is the only connection of the lake with Manila Bay. The percentage of chlorine diminished gradually as the stations became more remote from the Pasig River.

3. The salt increment was at first localized, but as it aged in the lake, it became more uniformly diffused. Thus, on June 29, the salt water was mostly confined to the northern portion of the west arm of the lake (probably in the region of stations 4 and 5 only);

by July 6, it had extended to the middle arm of the lake (as shown by stations 8, 9, and 10) and the northern part of the west arm (stations 4 and 5); on July 13, it reached over the west and middle arms (stations 1-11); but by August 31, 1936, the salt had already spread more or less evenly throughout the lake.

4. Taking the salt content in stations 1, 3, 4, and 5 from March, 1935, to May 28, 1936, as being general throughout the lake prior to the entrance of the salt water, it may be deduced that even the parts of the lake farthest from the Pasig River—such as station 15, which is near the end of the east arm of the lake—received their share of the salt increment as a result of the homogenization.

5. Once salt water has entered the lake, its elimination is a slow and gradual process. The lowering of the chlorine content is chiefly the result of diffusion in the lake water; undoubtedly, it is also lowered by gradual dilution from the numerous streams flowing into the lake.

The weekly chlorine content of the water at station 1 subsequent to August 31, 1936, is as follows:

DATE EXAMINED:		CHLORINE (PER CENT)
1936:		
November	12	0.0122
"	21	0.0121
December	2	0.0110
"	8	0.0103
"	15	0.0063
"	29	0.0085
1937:		
January	5	0.0078
"	12	0.0067
"	19	0.0074
"	26	0.0066
February	2	0.0074
"	9	0.0090
"	16	0.0097
"	23	0.0109
March	2	0.0089
"	9	0.0094
"	16	0.0111
"	23	0.0111
"	30	0.0090
April	6	0.0106
"	13	0.0093
"	20	0.0090
"	27	0.0096

These results give further evidence that it takes a very long time for the salt water to be eliminated after entry into the lake. Up to the present writing—a year after salt water was first noticed to have invaded the lake—the chlorine content of the lake is still very much higher than it was prior to the invasion. It is improbable that this continued high chlorine content of the lake water could be due to further and subsequent entry of sea water because since September, 1936, to April, 1937, the lake water level has been consistently higher than the mean sea level.

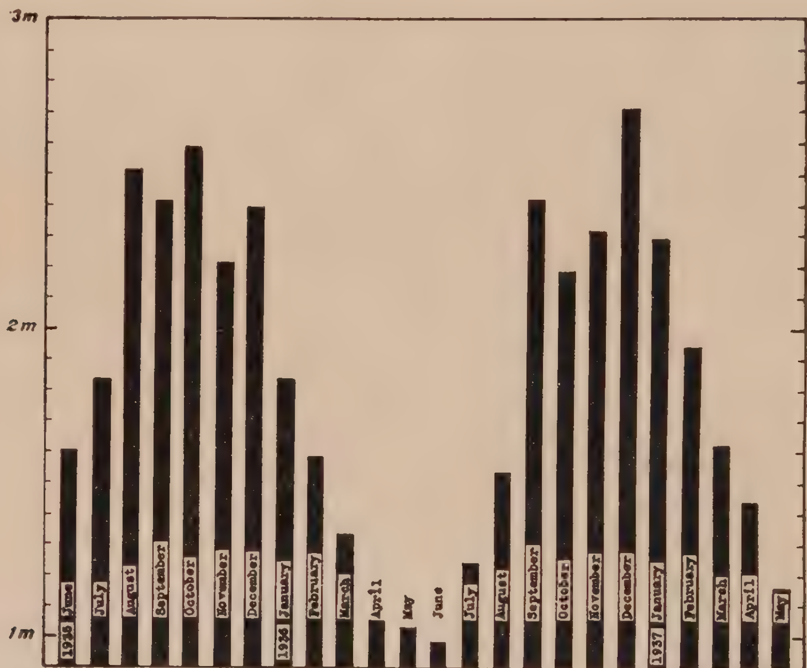

Chart 1.—Average weekly height of water level in Laguna de Bay, June, 1935, to May, 1937.

THE WATER LEVEL OF THE LAKE

The fluctuation of the water level in the lake from June, 1935, to May, 1937, is presented in weekly averages for the different months in chart 2. The data are obtained by taking the average of readings at the two stations established for this purpose, one at the College limnological station at Mayondon, and the other, in the town of Los Baños.

It will be seen in chart 1 that, as is to be expected, the water level in the lake is continuously rising or falling and is never stable.

During the period studied, it was lowest in June, 1936 (0.988 meter), and highest in December, 1936 (2.705 meters). The lowest water level was recorded on June 9, 1936 (0.94 meter), and the highest, on December 8, 1936 (3.01 meters). There was a difference of 2.07 meters between the lowest and the highest water level during the period studied.

In a statement above, it was pointed out that salt water entered the lake from Manila Bay. It can be seen here that this salt water must have entered Laguna de Bay some time in June, 1936. Further strength is lent this belief by the fact that for the greater part of this month, the high water tide in Manila Bay, according to the tide table [5], was higher than the water level in Laguna de Bay, reaching a height of 4.7 feet (1.43 meters) over the mean sea level on June 30.

It was also observed, after the lake had been invaded by salt water, that where the chlorine content was high, the lake became much clearer than it had been in these parts prior to the entry of the salt water, the water having apparently lost much of its usual turbidity.

Observations on the lake fauna

Any appreciable increase in salinity of a fresh water lake, like Laguna de Bay, if it persists too long, as it does in the present case, is bound to exert a very profound effect on the lake fauna. The "depletion" of certain species is probably traceable to this change.

As the salt water invaded the usual *pukot*-operating [6] areas in the deeper portions of the lake to the west and south of Talim Island, these places had to be abandoned by pukot operators, for the good reason that there were no fish to catch. After the salt water was already more or less homogenized in the lake, pukot nets were again operated in these places. Now, in Laguna de Bay, pukot catch consists mostly of "kandule", *Arius* spp. "Kandule", apparently, leave their usual habitat as these are invaded by salt water.

"Kabasi", *Anadontostoma chacunda* (Hamilton-Buchanan), and "hipong-suahe", *Penaeus* sp., are two normally marine species. These are not ordinarily caught in Laguna de Bay, and to our knowledge, the last time prior to 1936 that "hipong-suahe" was caught at Los Baños was in 1932. These two species were caught in some abundance when the salt water had reached Los Baños. Up to April, 1937,

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[5] U. S. Coast and Geodetic Survey in Manila Daily Bulletin, June 1, 1936.
[6] Drag-seine.

"hipong-suahe" was still caught at Los Baños, although in limited numbers.[7] Now, during the period from November 12, 1936, to April 23, 1937, in which "hipong-suahe" was still being caught in Los Baños, the water salinity ranged from a low of 0.0063 per cent (December 15) to a high of 0.0122 per cent (November 12), with an average salinity of 0.0093 per cent. This average is only 0.0079 per cent higher than the average salinity (0.0024 per cent) previous to invasion of the lake by salt water. The average salinity previous to invasion of the lake by salt water was lower by only 0.0039 per cent than the lowest, and by only 0.0098 per cent than the highest salinity during this period of fourteen weeks. It seems, therefore, that in Laguna de Bay, the presence of "hipong-suahe" can be used as a zoömeter to detect invasion by salt water.

Vivipara angularis Müller was relatively scarce in at least the few months immediately preceding the entrance of salt water in the lake. Within two months after the invasion by salt water, the snail had become very abundant.

SUMMARY

The present paper is a record of certain physical changes which were observed in Laguna de Bay, the largest lake in the Philippines. It also records the more evident accompanying changes in the lake fauna. The time covered was from May, 1935, to June, 1937.

There was a difference of 2.07 meters between the highest and the lowest water levels of the lake during the period studied. The lowest, 0.94 meter, was observed on June 9, 1936, and the highest, 3.01 meters, on December 8, 1936.

From June, 1935, to May, 1936, the average chlorine content of the lake water was about 0.0024 per cent. During the dry season, the salinity increased to about 0.003 per cent. This general slight increase in the salinity of the water in the lake is believed to be due to rapid evaporation in the lake water and less volume of water coming into the lake from the feeding streams during the dry season.

In June, 1936, the chlorine content in some parts of the lake increased suddenly to 0.0922 per cent, or an increase of 27.81 times over the average salinity observed between June, 1935, and May, 1936. This salinity is due to an inflow of sea water from Manila Bay,

[7] The fish corrals, *baclad-süd*, in which "hipong-suahe" were being caught near Los Baños, were drawn out of the water in the latter part of April, 1937. Hence, further observation on the presence of "hipong suahe" was stopped.

through the Pasig River, at a time during the month when the high-tide water level in the bay was much higher than that in the lake.

The invading sea water was, at first, localized in the western arm of the lake near the Pasig River, but as it aged in the lake, it became diffused in the lake water. As a result of this diffusion, all parts of the lake received their share of the salt increment. The water in the eastern part, farthest away from the Pasig River, received the least increment in salt content.

It is by this gradual diffusion in the lake, supplemented, undoubtedly, by the gradual dilution of the lake water from the lake tributaries, that the subsequent lowering of the salt content is chiefly accomplished. The lowering of the salt content after invasion by sea water is a slow and gradual process, and much of the salt increment in June, 1936, had not been eliminated by June, 1937, one year after invasion of the lake.

Invasion of the lake by salt water resulted in unusual transparency in the lake water, the water having lost much of its usual turbidity.

With the increase in salinity of the lake water, an increase in relative abundance of certain forms of animal life in the lake and apparent decrease in others were observed. "Kandule", *Arius* spp., apparently, avoids the high salt-water increment; they leave their usual habitat as these are invaded by salt water. "Kabasi", *Anadontostoma chacunda* (Hamilton-Buchanan) and "hipong-suahe", *Penaeus* sp., two normally salt-water species, became fairly abundant in the lake near Los Baños, where they were not ordinarily caught. *Vivipara angularis* Müller became very abundant within two months after entry of the salt water. "Hipong-suahe", *Penaeus* sp., among the species observed, is the most responsive to slight changes in salt content, and may be of value as a zoömeter for the detection of invasion of the lake by salt water.

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TABLE 1

Percentage of chlorine in lake water from June, 1935, to May, 1936

DATE OF OBSERVATION	STATION 1	STATION 3	STATION 4	STATION 5
	per cent	*per cent*	*per cent*	*per cent*
29 VI 1935	0.0020	0.0020	0.0020	0.0020
17 VIII 1935	0.0026	0.0022	0.0024	0.0025
22 IX 1935	0.0024	0.0023	0.0022	0.0022
25 X 1935	0.0024	0.0021	0.0023	0.0024
27 XII 1935	0.0024	0.0022	0.0023	0.0022
25 I 1936	0.0022	0.0021	0.0023	0.0023
29 II 1936	0.0024	0.0023	0.0023	0.0023
30 III 1936	0.0021	0.0025	0.0026	0.0026
29 IV 1936	0.0030	0.0029	0.0029	0.0029
28 V 1936	0.0029	0.0031	0.0032	0.0032
Average ...	0.0024 ± 0.000068	0.0023 ± 0.000075	0.0024 ± 0.000077	0.0024 ± 0.000078

TABLE 2

Weekly percentages of chlorine in various parts of Laguna de Bay from May 28 to August 31, 1936

STATION NO.	MAY 28	JUNE 27	JUNE 29	JULY 6	JULY 13	JULY 20	JULY 28	AUGUST 2	AUGUST 9	AUGUST 31
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	0.0029	0.0096	0.0098	0.0139	0.0137	0.0229	0.0207	0.0227	0.0264	0.0224
2	—	—	0.0265	—	0.0272	0.0263	0.0372	0.0352	0.0317	0.0243
3	0.0031	0.0187	—	0.0185	0.0677	0.0337	0.0395	0.0289	0.0314	0.0250
4	0.0032	0.0667	—	0.0461	0.0208	0.0386	0.0291	0.0278	0.0218	0.0206
5	0.0032	0.0922	—	0.0391	0.0502	0.0333	0.0274	0.0250	0.0293	0.0252
6	—	—	—	—	—	0.0263	0.0362	0.0365	0.0246	0.0255
7	—	—	—	—	—	0.0330	0.0283	0.0324	0.0248	0.0245
8	—	—	—	0.0140	0.0175	0.0233	0.0232	0.0111	0.0048	0.0235
9	—	—	—	0.0629	0.0352	0.0378	0.0351	0.0369	0.0270	0.0239
10	—	—	—	0.0419	0.0379	0.0433	0.0396	0.0365	0.0368	0.0249
11	—	—	0.0346	0.0404	0.0353	0.0412	0.0384	0.0384	0.0369	0.0261
12	—	—	0.0305	0.0303	0.0386	0.0210	0.0220	0.0389	0.0288	0.0262
13	—	—	0.0092	0.0060	0.0051	0.0100	0.0188	0.0089	0.0204	0.0147
14	—	—	0.0030	0.0063	0.0066	0.0123	0.0034	0.0096	0.0091	0.0111
15	—	—	—	—	0.0074	0.0047	0.0098	0.0064	0.0089	0.0051

THE PROBABLE NATURE OF "CADANG-CADANG" DISEASE OF COCONUT[1]

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At the invitation of the Agusan Coconut Company the writer visited the San Miguel Estate on San Miguel Island, Tabaco, Albay Province, on April 21 to 23, 1931, to look into the coconut-disease situation in the plantation. At the time of the writer's visit the only important disease of the coconuts on the island was what the people of the Bicol peninsula called "cadang-cadang," which means growth-failure or running-out disease. In some sections of the estate 25 per cent of the coconut palms were infected. A study of the characteristic symptoms of cadang-cadang and of the conditions surrounding the diseased palms was made. As our knowledge of virus diseases at the College of Agriculture in 1931 was yet limited, the resemblance to virus diseases of the symptoms and effects of cadang-cadang of coconut was not then recognized by the writer. At that time it was generally concluded by people who saw the disease that cadang-cadang was produced by any one of the following factors or by a combination of these factors:

1. Presence of a hard pan close to the surface of the soil
2. Poor drainage or water table too close to the surface of the soil
3. Individual vitality of trees
4. Poverty of the soil
5. Unadaptability of the site for coconut culture
6. Root parasites

The supposition that cadang-cadang symptoms were brought about by one or more of these factors was more or less accepted. In his report of the trip to San Miguel Island, the writer also listed these factors as among the suspected causes of cadang-cadang.

As our knowledge of and experience with virus diseases of plants progressed, however, the writer noted the important similarities of symptoms and effects of cadang-cadang to those of well-known virus diseases.

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The writer's description of the disease which indicates the points of similarity to virus diseases are as follows: Coconut palms suffering from cadang-cadang may be readily recognized at a distance. The most conspicuous symptom of the disease is the yellowing or chlorosis of the leaves. This symptom is one of the most common manifestations of virus diseases. The leaves of coconuts suffering from cadang-cadang show at first an abundance of yellowish translucent spots. The small translucent spots gradually turn orange yellow. On the pinnae of the younger leaves the spots are small; they are about a millimeter in diameter. The spots tend to enlarge until their diameters are three to four millimeters. On account of the enormous number of these spots and of their tendency to merge together, the pinnae become yellowish or chlorotic in appearance. From a distance the crown of the diseased tree appears yellowish green, in contrast with the dark green leaves of nearby healthy trees.

The pinnae tend to appear more slender than those of healthy trees. Owing to the narrowing of the pinnae, they appear as though they are sparsely set on the petioles. There is also a pronounced tendency of the pinnae of diseased trees to bend over or break in the middle.

As the disease advances, the leaves gradually become smaller than those of healthy trees of the same age. On account of the contrast of color between the new leaves and the old foliage of diseased palms, those that are newly unfolded appear to be darker green than those of healthy palms.

Owing perhaps to the absence or reduction of chlorophyll, the blades of the pinnae of the middle leaves dry out, while those of healthy trees do not. Necrosis is another characteristic symptom of a number of different mosaic or yellows forms of virus diseases. As a consequence of the rapid drying of the pinnae, the leaves fall off much earlier than those of healthy plants.

Infected plants are stunted. They produce smaller and shorter leaves. The smaller and shorter leaves appear to be closely bunched up at the end of the trunk. Stunting is one of the most common results of infection by a virus disease. This result of infection is shown in the bunchy-top of abacá, Fiji disease of sugar cane, and temperate zone virus diseases, like peach rosette and wheat rosette.

The reduction of the size of the leaves is followed by a gradual tapering of the trunk. Eventually all of the leaves fall off and the trunk becomes a bare and pointed pole. The length of time it takes

the disease to kill a tree from the time the first symptoms appear varies; it seems evident that this is due to the vitality of the individual tree.

As soon as yellowing of the pinnae becomes noticeable, no fruits are formed, although spathes may be produced in abundance. The racemes dry out fast but they persist on the tree. In the bunchy-top of abacá, infected plants rarely, if ever, fruit. In an infected stool of abacá, only plants that do not show the symptoms of the disease bear flower.

A coconut tree in an advanced stage of the disease was felled on April 21, 1931. The bud did not show any abnormality. Neither were there evidences of parasitic organisms in the lesions of the leaves.

The loss of chlorophyll of the leaves and the subsequent drying of the blades of the pinnae seem to suggest that the leaves are unable to provide the roots with the required supply of manufactured foods. As a result, many of the roots of the diseased palm are discolored. Some are dead and rotting. The stele of the roots seems least injured but in many of them the cortical tissues are disorganized. In the writer's work on bunchy-top of abacá it was suggested that the rotting of the roots is a result of infection and that it is perhaps due to starvation.

Roots of infected trees in the San Miguel Estate were collected and examined in the laboratory at Los Baños. Several fungi associated with the decorticated roots were isolated to pure culture. Infection experiments using roots of young coconuts at Los Baños have shown that the fungi bear the same relation to the roots of the coconut that the various organisms isolated from roots of abacá infected with bunchy-top do to the roots of abacá.

It may thus be seen that cadang-cadang of coconut exhibits two of the three general types of symptoms of virus diseases—chlorosis and necrosis. It also shows the stunting effect, one of the most important results of infection with virus diseases, and the effect on fruit bearing.

GENERAL OBSERVATIONS ON ANIMAL HUSBANDRY IN INDIA [1]

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WITH FIVE TEXT-FIGURES AND ONE MAP

On the recommendation of the Assistant Head of the Department of Animal Husbandry, College of Agriculture, the Dean of the College and the President of the University of the Philippines authorized the writer to travel through India for the purpose of studying the livestock situation there. The writer left Manila on March 30, 1937, arriving at Colombo, Ceylon in the morning of April 8, 1937. The trip was made in four laps: (1) Colombo to Madras, with stops-over at Madura, Pasumalai, and Trichinopoly; (2) Madras to Bombay, with stops-over at Bangalore, Hosur, Mysore City, and Poona; (3) Bombay to Delhi, with stop-over at Agra; and (4) Delhi to Calcutta, with stops-over at Cawnpore, Lucknow, and Allahabad. On his way back to the Philippines, the writer had an opportunity to visit Burma for four days. This Indian trip covered a period of forty-five days, excluding the time spent in travel to and from India. In view of the vastness of the country, the time spent in the study of the subject was rather short. However, there are certain advantages in trips of short duration when one looks at big problems with well-defined objectives in mind; the broad outlines of the subject can be clearly seen, without getting lost in minor details.

SOUTHERN INDIA

On the great plains of Southern India from Rameswaram to Madras City, passing through Madura and Trichinopoly, one sees numerous herds of oxen and water buffaloes. Along the coast lines, the cattle are very small, measuring only about three feet at the withers, not unlike those predominating on the island of Ceylon. The water buffaloes, likewise, were small. Marked heterogeneity in types and conformation was a characteristic feature of these cattle, the majority of which were in very poor condition. Old decrepit cows were a common sight.

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[1] Experiment Station contribution No. 1184. Received for publication July 4, 1937.

Grazing side by side with these ill-looking cows were countless flocks of sheep and goats herded together in numbers varying from about 50 to 100. Miniature-sized donkeys which were just a bit larger than goats could be seen here and there. In the coastal plains, ponies and horses were conspicuous by their absence. But closer to the city of Madras small-sized horses began to make their appearance. Occasional chickens stood out among the more numerous hawks seen in Indian villages. The abundance of Indian crows everywhere would lead people unacquainted with the game of animal husbandry to think that the ubiquitous birds play an important rôle in the economics of India.

Fig. 1.—A large Indian village in Madura, Madras Presidency

Since people of Southern India are predominantly Hindu vegetarians, the large numbers of oxen and water buffaloes, as well as goats and sheep, are used to produce dung which constitutes about the only means of maintaining the fertility of the soil. A peasant owning about 100 sheep and goats or more can ordinarily make a fair living, even though he may not own any land. Recognizing the fertility value of dung, landlords will pay sheep and goat owners for pasturing animals on their paddy or rice lands soon after harvests. Cattle owners are paid more, owing to the larger amounts of dung left on the soil after pasturage. By this system, although paddy lands in Southern India according to report are over two

thousand years old, they are still productive. Additional income can be obtained from mutton and chevron which are about the only meat eaten by some Hindus. The mohair and coarse wool furnish materials for the manufacture of carpets; and although the Hindus themselves do not partake of any food containing beef, they are not averse to selling bullocks to Mohammedan and other people whose beliefs do not rule beef out of their menu.

Towards the city of Madras the prevailing cattle seen were the Ongole, better known in the Philippines as Nellore. In the vicinity of Madras City the general run of this breed of cattle was large, and it is as draft animals that the Ongoles have become so well linked in the economy of the villagers in Madras Presidency. The cows are used for milking in the villages, but they are not high yielders. Castration is not practised, judged from the very large number of old decrepit bulls used for draft purposes not only in the villages but also in the cities of Madura, Trichinopoly, and Madras.

LIVE-STOCK RAISING IN THE STATE OF MYSORE

According to information gathered from Indians who were in a position to know the livestock of their country, none of Mysore breeds of cattle are good milkers. The Amritmahal and Hallikar, two of the best breeds of Mysore cattle, yielding 6 pounds a day, are considered superior cows in Mysore. Reports crediting some Amritmahal cows with a daily milk yield of 12 pounds at the height of their lactation are of very doubtful verity.

The Amritmahal cattle are essentially draft animals, noted for endurance on the road. In speed they are said to be unsurpassed by any other Indian draft type of cattle, trotting on the average of about ten miles per hour. It is as draft oxen that they have been bred by the Military Department during the last one hundred years. The Government of Mysore has always kept a large number of Amritmahal cattle in small herds, aggregating about 9,000 head, since it is from these herds that the Military Department draws its supply of draft bullocks.

It has been the experience of cattle raisers in Mysore that whenever the cattle are allowed to live under a semi-wild state, subsisting entirely on what they can pick up on pasture lands, the stock degenerates. With reference to the Amritmahal cattle of the Government of Mysore, after the bad season in 1929 when the pastures continued for long to be poor and the animals were forced to

move to the jungle, the losses through death and deterioration of the size of the animals became alarming. Adopting a general plan for improvement, the Government live-stock experts selected 100 of the best cows and 4 of the best bulls from about 6,500 animals still remaining. Breeding work on these choice animals was directed towards two definitely divergent lines—for dairy and for draft.

After about five years of work, however, it was realized that the work had been greatly hampered by frequent changes in policy of the government administration as well as by the changes in personnel in the Department of Agriculture. To overcome this difficulty a scheme was adopted the main feature of which was gradually to place the work on cattle improvement in the hands of men not connected with the government.

PLANS TO DEVELOP A DAIRY TYPE OF AMRITMAHAL CATTLE

The milk records of the selected Amritmahal cows disclosed the existence of cows which yielded as much as 2,000 pounds of milk (900 liters) per lactation. This fact indicates that it might be possible to build up a dairy type from the Amritmahal by using the high yielding cows as foundation stock. The plan is not to develop a dual-purpose type, but rather to form a truly dairy breed by methods similar to those employed in the formation of the Red Scindi breed. According to the Mysore live-stock experts, efforts toward building up dual-purpose animals lead nowhere.

In an effort to raise the level of production of the promising dairy Amritmahal cows, the methods of feeding used for these cows are those on dairy principles; namely, from June to January, the milking cows are not fed any concentrates. During the remaining months their daily ration includes 3 pounds of concentrates consisting of a mixture of groundnut (peanut) cake, wheat bran, and rice bran in the proportion of 3 : 1 : 1. To such a ration sufficient amount of sterilized bone meal and common table salt are added to make about 2 per cent of the concentrates. The dry cows subsist entirely on pasturage and roughage. When the pasture grasses are scanty, owing to failure of rains, the cows are sent to the jungle where some grazing is available.

Some rather interesting findings have cropped out of this work. For example, several fairly high producing cows had to be discarded from the dairy because whenever they were turned loose in accordance with the method of management described in the foregoing paragraph, their milk yields diminished greatly after roping.

Also, there were cows which would not take the bull while they were nursing their young; while other cows stopped yielding milk entirely the moment they were covered by the bulls. Such undesirable characteristics as these must be bred out of the dairy; otherwise, much loss will be sustained.

To correct the prominent defect in Amritmahal cattle as draft animal, that is, the sudden droop of the rump, crosses with Hallikar animals which do not possess this defect have been made. This work was started at Ajampur in 1929, and the results so far obtained are encouraging in that the abrupt slope of the rump has not appeared among the progeny. Also, the facial markings of the Amritmahal, a fancy point which the people in the meadow parts of Mysore prize highly, have been transmitted to the offspring. The work at the time of this visit consists in fixing the type of cattle so as to be able to produce breeding bulls in numbers sufficiently large to be distributed to the Mysore villagers. Some of the points aimed at in this work are to increase the birth weights of the calves and to shorten the ages at first calving.[2]

WATER BUFFALOES

Mysore water buffaloes are very small and generally poor milkers. The Mysore Government, therefore, found it necessary to bring into the state some of the noted buffalo cows from Northern India. The breeds found satisfactory to raise were Surrat, Ahmadabad, Murrah, and Bagalkote. The Murrah buffaloes have yielded in Bangalore from 4,000 to 5,000 pounds of milk (1,800 to 2,260 liters) per lactation. Progeny from these cows are sold out to the villagers as soon as they are produced, in order to improve the native stock.

SHEEP AND GOAT RAISING ON THE DECCAN PLATEAU

On the table lands of the Deccan Plateau, from Hindupur to Raichur, a distance of about 200 miles, one finds the most concentrated effort in India upon sheep and goat production. A large proportion of the twelve million sheep which are credited to the presidency of Madras by the live stock census for 1935 are found in this section of the country.[3] Anantapur is the center of the mut-

[2] Anon. (1936). Live Stock work in Mysore. 10 pages. Printed by the Superintendent at the Government Press for the Department of Agriculture, Mysore State, India.

[3] Anon. (1936). Live Stock Statistics for 1935. Report of the Fourth Census of Live Stock and Agricultural Implements and Machinery held in 1935. Manager of Publications, Delhi.

ton and chevron trade in the section, supplying the cities of Bangalore, Bombay, Madras, and Mysore with abundant meat year in and year out. The low rainfall in the Deccan Plateau, averaging only about 22 inches annually, renders the extensive lands of the plateau unsuitable for crop culture; but the grasses that can grow under such a condition afford adequate feed for the production of sheep and goats.

The prevailing colors of the sheep found in this region are black and white. The Bellary sheep, so well known throughout India, trace their origin to this region. With the object of evolving a white breed of Bellary sheep which will produce an average quantity of wool and a good carcass, work on breed improvement was started some years ago at Hosur, Madras Presidency. While considerable advance has been made in that direction,[4] some difficulties have been encountered. It was found that whenever white occurred in homozygous condition, it was usually associated with weakness in constitution; that is, there seems to be a strong correlation between pure white and lack of constitutional vigor. Why black sheep should be better adapted to the hot dry climate of the Deccan Plateau than their pure white sisters is not surprising when one takes cognizance of the fact that the black water buffaloes, kept side by side with sheep even in hotter regions of India, seem to carry through without much discomfort.

PIG BREEDING

The indigenous pig of India is black, with arched back, flat sides, and undeveloped hams. Its snout and legs are disproportionately long. Its rather diminutive body is well covered with coarse hair and bristles. The few people who breed and rear pigs, usually under very insanitary conditions, have done little or nothing to elevate these animals from the despised position they now hold.

In an effort to improve the quality, size, and conformation of the indigenous pigs, experiments have been carried out in the cattle farm of the Imperial Government at Hosur, Madras Presidency, by crossing country sows with improved boars imported from Australia and other countries. The writer was informed that the Berkshire boar was found best for this purpose, since it has the power of transmitting its good qualities speedily to the progeny. Moreover,

[4] Anon. (1934). India in 1932-1933. Manager of Publications. Delhi, India.

of all the different breeds of imported pigs that have been bred and reared in India, the Berkshires seem to be the only breed that has stood the Indian climate better than any other breed.

CATTLE IN AND AROUND OLD AND NEW DELHI

On the whole the cattle in and around Delhi, Punjab State, are larger than those in Southern India. The oxen most commonly seen measure about five feet and five inches at the withers. Although in Delhi at the time of this visit the temperature ranged from 100 to 109°F (37.7 to 42.7°C) under shade and nearly all the grasses had dried up, the animals were in fair condition, with their large

Fig. 2.—Berkshire pigs from Australia at the cattle farm of the Imperial Government at Hosur, Madras Presidency.

frames filling up evenly. The breeds which the writer could recognize were Hissar or Hariana, Dhani, Montgomery or Sahiwal, and some mixed breeds.[5]

Information has it that in the southern part of Punjab State the Hariana (Hissar) is the breed preferred, while in the northern part, particularly in that part of the State called Rawlpindi, the Dhani breed predominates. In the western part of the state the

[5] Inasmuch as there is a great diversity in the spelling of the names of Indian cattle in Indian publications, the writer adopted the spelling used in the Proceedings of the Animal Husbandry Research Workers' Conference and similar publications of the Manager of Publications, Delhi, India.

Sahiwal cattle are more common than the other two breeds. The Hissar is a recent introduction in Delhi. The propagation of this breed of cattle in Delhi is being backed up by the present Viceroy of India who is greatly interested in the improvement of live stock. He has donated a number of high class bulls belonging to the Hissar breed to the villagers in and around Delhi, and these bulls are gaining in popularity. The Imperial Government of India has a cattle farm at Hissar where this breed of cattle is being improved under government control. Villagers have first option on the bulls produced from this cattle farm.

Castration of animals. In direct contrast to the situation obtaining in Ceylon and Southern India, where all the male cattle one sees are uncastrated, in Delhi every male animal over three years of age, except those intended for breeding purposes, are unsexed. The writer was informed in the New Delhi Veterinary Hospital that the castration of male oxen started with government sanction about twenty years ago. Animals with no particular merit are prevented from breeding when about two or three years old. The results of such a practice in promoting uniformity of dairy type and in increasing high yield have been so marked that at present the villagers are coöperating with the work.

The writer visited a small veterinary hospital about eleven miles from Delhi, where many young bulls are castrated every week. From the array of castrating instruments on display, one is apt to conclude that castration of animals has become the principal function of the hospital. The veterinarian in charge of the hospital stated that for about five years now nearly all castrations have been done by the use of Burdizzo pincers owing to the effectiveness of the instrument and to the fact that no visible wounds on the animals are produced. The slipping off of the spermatic cord to either side of the crushing edge of the pincers, so frequently met by inexperienced castrators in the old models of the pincers, has been made almost impossible with the new models in which a knob is provided at each end of the crushing edge.

Buffaloes. Three kinds of buffaloes were seen in and around Delhi. These buffaloes were in small dairies owned by natives of which the following were visited: Jhil Koranja and Dhula Kiran, both of which are almost on the bank of the Jumna River. The Murrah breed, locally called Kuni, meaning ram's horn, is preferred by many, but the Mehsana and Surti are also popular. The Mehsana breed, better known in the Bombay Presidency as Kathiawar, has

been found in Delhi to give a higher yield of milk than the Surti. In Delhi, the word *surti* means ordinary stock with long horns and bad features. The average yields of the buffalo cows in the dairies visited are from 15 to 16 pounds, or about 7 liters, a day for the Murrah and Mehsana. The Surti gives much less milk. Specially high yielding Murrah and Mehsana buffalo cows are said to produce about 25 pounds, or 11 liters, a day at the height of their lactation.

SIZES AND CLASS TYPES OF CATTLE AS AFFECTED BY VARIATIONS IN CLIMATE

Old mystic India lies from 8 to 38 degrees north latitude and between 66 and 92 degrees east longitude. It has an area of about 1,800,000 square miles spread out in the form of a V, the base of which stands close to the equator. The southern half of the country lies in the tropical zone, while the northern part is in the subtropical and temperate zones. The greater portion of India enjoys six consecutive seasons a year; namely, summer, rain, autumn, pre-winter, winter, and spring. The greatest extremes of heat and cold are in the north-western part of the country. Around the cities of Madras, Bombay, and Calcutta, on account of their proximity to the seas, the climate is very equable, the temperature hardly rising above 106 °F (41°C), in the summer months nor falling below 52°F (11°C) in the coldest season. The perpetual snow of the Himalayas keeps the rivers flowing. The wettest climate is said to be in Assam State, where in some sections the annual rainfall is never below 400 inches (1,016 cm.) Baluchistan is said to be the driest section, the annual rainfall averaging about 3 inches (7.6 cm.); and between these extremes is a wide diversity of climates. In the southern part and somewhat centrally located is the Mysore State whose general elevation rises from about 2,000 to 5,000 feet above sea level and generally consists of an undulating table-land, much broken up by chains of rocky hills.

The differences in geographical and climatic conditions seem to have produced profound effects on the live stock. On the whole, South Indian cattle are very small, the greatest majority of the cows measuring not more than three feet at the withers. As one goes farther and farther northward, he notices a gradual improvement in the size, not only of the bovine and bubaline cattle, but also of other classes of animals. In the Punjab State, for example, one looks in vain for small-sized animals. The average cow measures about five feet at the withers; and steers standing five feet and five inches are very common. The buffaloes in the Punjab State are noted for their

size and for their extremely well-developed udders; while in the southern part, the buffaloes present an undersized, almost degenerate, appearance.

These marked progressive differences in the size of cattle from southern to northern India, although presumably the animals were subject to identical method of management, intrigues one to speculate as to probable explanation. Undoubtedly, the humid climate with all its effects must have played a part. But humidity alone could not have produced the entire result. Other factors must have been operative. When a group of animals is left to the influence of natural selection, only those most fitted to a given set of environmental conditions survive. In Southern India, with its high seasonal rainfall alternating with hot, moist, and protracted dry season, continuous abundance of feed for animals is impossible. The abundance of rain during the rainy season allows a luxuriant growth of pasture grasses During such a time animals overfeed themselves, but not for long. At the onset of the dry season the grasses soon wilt away. The hot humid atmosphere causes the dried grasses to deteriorate by decay rather rapidly.

Animals must, therefore, feed on whatever wilted grasses still existing on the ground and on feed remaining unspoiled, the supply of which must necessarily be low. When these are consumed, all animals must undergo protracted periods of enforced fasting. Hence, large animals requiring larger amounts of feed to carry them through the dry season are eliminated, for they are unable to find sufficient feed with which to maintain themselves. On the other hand, small animals requiring relatively less feed are able to tide over until the next rain.

It is only in modern dairy establishments that large types of cattle can be found in Southern India. These animals, however, are not left to forage for themselves in a partly wild state. In the dry season they experience no want in feed. An adequate supply of straws is stocked under shelter and large amounts of silage are made. Abandoned to their fate, these large types of cattle degenerate in number, as well as in size.

In the northern part of India the low atmospheric humidity prevents spoilage of feeds grown during the previous rainy season, even when these are left in the open. The writer reached the Punjab just about the end of the summer months, and he found an abun-

dance of feed. Wheat and oat straws stacked in huge piles in the open fields crumbled in the palm of one's hand, but they were in good state of preservation. Animals fed on nothing but these thrive well.

THE POSITION OF THE COW IN THE ECONOMY OF THE INDIAN PEASANTS

The cow and the Indian villager

The fourth livestock census of India[6] reports that at the close of the year 1935 there were over 167 million head of oxen and water buffaloes in British India and in the Native States. Excluding the states of Bengal, Bihar, and Orissa, complete statistics for which were not reported, the total number of sheep in British India in 1935 was 40 millions; goats, 42 millions; horses, ponies and mules, 2½ millions; donkeys, 2 millions; and camels, 1 million. Ploughs numbered 33 millions and carts, 9 millions. India contains, according to Higginbottom,[7] more than one-quarter of the world's cattle, though she has only about one-sixth of the world's human population. This means that India has many more cattle in proportion to her area and population than any other comparable area in the world.

That there should be so disproportionate a ratio between human population to cattle population in India, as compared to other kinds of live stock, is not surprising when one considers the dietary of the Indian villagers, who, according to Roy,[8] constitutes nearly 90 per cent of the human population of India.[9] Milk and the by-products of milk provide more than fifty per cent of the Indian villager's daily food. Can there be a more compelling motive than self-preservation in the institution among Hindus which places the cow among the deities? In fact, the Indian village economy is firmly hinged on the cow. It is she who supplies the bullocks which till the land. It is she who produces the bulls needed for the transportation of the products on the farm to markets. The only conveyance of the average Indian villager for his family and for himself is the cart drawn for the most part by bullocks. The dung provides fertility to the soil and, in case of need, the fuel with which food is cooked. When the bull dies, his hide provides the materials for the shoes of the villagers' family and water bag with which he sprinkles

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[6] India Live-Stock Statistics. (1936). Report on the Fourth Census of Live-Stock and agricultural implements and machinery held in 1935. pp. 1-20. Manager of Publications. Delhi, India.

[7] Higginbottom, Sam. (1937). More and better milk. The Allahabad Farmer. 11 (2) 65-70. March, 1937.

[8] Roy, Dhirendra Nath. (1930). The Philippines and India. v + 211 pp. Oriental Printing, Manila.

[9] The population of India is placed at 354,000,000.

his garden and yard. The bones furnish numerous products with which to beautify the huts. Even the cloths worn by the villagers are attributed to the cow, for were they not made from cotton raised on lands tilled by the cows' young?

Woe unto the Indian villager who is too poor to own a bullock! Most parts of India are dry, and the fields have to be irrigated with water drawn by Persian wheels. Only by the use of these wheels can crops be produced in certain parts of India, and villagers who do not possess bullocks must themselves work on the wheels. In addition to supplying the bull and bullocks, the cow furnishes the milk for the villager's family. Milk is consumed as whole milk. Curdled milk diluted with water is a favorite drink with the Hindus. Excess milk is converted into clarified butter, called *ghee*, which is needed for cooking ordinary food and choice Indian delicacies and sweetmeats. No Indian formal ceremony is complete without some food containing milk.

The dung of the cow is considered healthful and must be saved. Mixed with fine clay, it affords excellent material for coating the floor and walls of the villager's hut. Even to this day educated Hindus affirm that such coatings have disinfecting properties. When a villager expects a visitor, the wife must be advised beforehand to enable her to give her home a fresh coating of cow dung. The urine of the cow is oftentimes used for medicinal purposes. It is for these and other reasons that among Hindus the cow has virtually become an indispensable member of the family. To possess a good cow is the one cherished ambition of a Hindu villager; and to own the best bull of the village is the glory of his temporal ambition.

The Hindu lawgivers, we are told,[10] know the character of their compatriots only too well to imagine that simple prohibition and punishment would not suffice to save the lives of these precious cows. Hindus would eat fish, but most of them live far from the coast or from the rivers which supply this commodity. In the past, Hindu villagers often partook of beef in the privacy of their own families or in company with close relatives or intimate friends. So, calling religion to their aid, lawgivers deified the cow. To kill a cow, according to the principle of Hindu law, is not only a crime, but an awful sacrilege, a deicide, which can only be expiated by the

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[10] Dubois, Abbé J. A. (1905). Hindu manners, customs and ceremonies. (Translation from French into English by Henry K. Beauchamp). xxxiv + 722 p. and index. 3rd edition. Oxford: Clarendon Press.

death of the offender, while to eat the flesh of the cow is a defilement which cannot be purified.

So effective has the principle been carried out that in time the cow-worship institution has encroached upon other forms of live stock. Eating the flesh of buffaloes, horses, elephants, etc., and in fact, everything that comes under the head of large meat, inspires all Hindus, Pariahs excepted, with almost as great an abhorrence as the flesh of the cow or ox. There is the same idea of defilement connected with it. The flesh of goat and of sheep and, to a certain extent, that of poultry is the only meat allowed in the orthodox Hindu family. Then, too, there are strictly vegetarian Hindus, who, refusing to eat meat in any form, would consume only sparingly of milk from goats, buffaloes, and ox. The more intelligent of them can not be persuaded to take cheese for the reason that in the manufacture of this valuable product rennet obtained from calves' stomachs is used.

Such a philosophy, which seems so simple and yet so weird, has had one rather definite effect on the live stock of India; namely, over-production of all types of animals, both domestic and wild. The presence of innumerable infectious and dangerous communicable diseases has proved totally ineffective in checking the reproduction of animals. India, as a whole, has done little towards developing efficient domestic animals even for her own use for the reason that she has denied herself the use of the most important tool for improvement—selection. She has taken everything that Mother Nature produces, with the result that at present India has far too many animals for the food supply available for them. Higginbottom [11] states that these surplus cattle are at present the most serious competitor of man for the produce of the soil.

Students of economics attribute the growing poverty of the Indian villagers to their practice and custom of dividing their land holdings equally among their off-spring. Each succeeding generation gets smaller and smaller parcels of land, and, when the holdings have been rendered too small to be operated on an economic basis, such holdings generally go to landlords and money lenders, while the peasants are thrown under serfdom. Usury is a recognized institution everywhere in India; and there is no limit to the rate of interest charged. One anna per month for every rupee loaned is, I am told, the common rate, and money lenders have been known to exact the extortionate rate of 100 per cent per year. Happily,

[11] Higginbottom, Sam (1937), *Op. cit.*

the cupidity of these money lenders often ends in their over-reaching themselves, for only people who are ruined and absolutely impecunious will consent to pay such interest, and consequently the greedy creditor often loses both interest and capital. There has been no improvement in this direction, I am informed, despite various proposals made by the government to legislate on the matter.

At present nearly 25 per cent of the Indian villagers work as serfs on lands where they get only one-third of the crops they produce. They continually sink deeper in debt. Much concerned about the growing poverty of the villager, the Indian Congress has sponsored a gigantic plan of general rehabilitation. Rural reconstruction work, also sponsored by the Government, has been in operation for some time. Under such a plan the large tracts of lands now in the hands of landlords, who have no other interest than to receive two-thirds of the crops, will be divided into smaller holdings and made available to needy peasants. Technical institutions in agriculture and in arts, staffed by very capable men, are not lacking throughout India, and in time the plight of the Indian villagers might be solved.

The problem of India is not lack of natural resources, for it has all, but rather the apparent impossibility of harmonizing present developments in the science of agriculture with the customs, traditions, and superstitions of the village men as regards their relationship with livestock with which they have surrounded themselves, on one hand, and with their gods on the other. It has taken hundreds of years to build up these customs and traditions.

Dairying in the villages

The cow has so long been associated with the Indian villager whose life depends much upon it that a family without a cow is inconceivable. Upon being separated from the paternal home, usually after marriage, even the poorest couple must have at least one milking cow. They have it in the Indian mythology that Krishna, the greatest incarnation of the Hindu god, was a natural lover of animals. When a boy of about ten years of age, he served as a herdsman, taking it upon himself to lead a large group of cows to the pastures. While the animals were grazing, Krishna would sit beneath the soothing shade of some tree and play a flute. It was with the use of the same instrument that he would call the cows back to the barns when grazing time was over. Because of this, Krishna (*gopalan*) became the chief divinity of the Hindu cultivator, and his mistress, Radha, the principal *gopi*, meaning cow-herdess, amongst

sixteen hundred women of the same occupation, received equal adoration. The sports and amours of Krishna and Radha form the subject of the cultivator's daily meditation. The institution of repetition of the name Krishna, called the sacrament of Hari-náma, is observed by men and women at least twice a day—once before the noonday meal, and again after sunset.

Thus, serving the cow has become a sacred duty not only of the children but also of all members of a village community. No task is more honorable than to take care of the cow. When in the barn, boys and girls stay by her side to catch her dung as it is voided without touching the ground and immediately manufacture this into cow-dung cakes. The birth of a calf is looked upon with no less reverence than the birth of a child. They follow this cow and her calf to their grazing ground. To serve the cow is a great privilege. To be able to give it feed personally is an honor. To groom it is a duty that pleases god. No wonder the village cow is so tame!

Unfortunately, however, the average Indian village cow is a scrub. The cow-worship system, having been carried so far, affected adversely the improvement in milk yield. A poor producing cow cannot be culled out or given away even when too old to be of any use. Hundreds of thousands of old cows in India are dragging villagers to misery.[12] In his short stay in India the writer saw hundreds of cows which normally should have gone to the block because they are so poor in type and conformation and yield so little milk, but villagers stick by them in a vain effort to squeeze every drop of milk from their miniature teats till near bleeding point. The average cow in most Indian villages does not yield one liter of milk a day at the height of its lactation, but there are so many of these poor cows used for dairying that the total milk obtained from them is like little drops of rain gathered together into large pools. Dairying in most Indian villages is not an industry of any magnitude. Each family generally produces barely enough milk for home use, with nothing or very little to sell. In Madura the writer saw a number of instances when a village boy travelled many miles on foot under the hot sun to barter one pound of milk for grain; and got less than two pice for the product. Adulteration of milk is a common practice. Curdled milk is often treated in the same way; that is, by adding any substance that looks like curlded milk. So rampant is the adulteration of *ghee* that researchers of the Indian Institute of

[12] Higginbottom, Sam. (1937). *Op cit.*

Science [13] have found it necessary to conduct experiments on methods of detecting the many adulterants used, thus enabling them to devise means of protecting this important diet from being exploited by many dishonest producers.

The conditions described in the foregoing paragraphs are true particularly in small villages in Southern India. Fortunately, in the villages in Northern India, particularly in the Punjab and Sind, conditions are somewhat different. In these districts dairying in the villages constitutes an important home industry. The predominance of the Moslem population in these districts must have helped greatly in overcoming the barriers against improvement of the animals set by the customs and traditions of the Hindu population. That some sort of selective breeding has taken place, there is no doubt. But the laws of economics have had their share in the betterment of the stock. People looking for good milkers look up to the North. Cattle market days have been developed in order to facilitate the traffic of dairy cattle. On such days hundreds of peasants from distant places make their pilgrimage to Sind and the Punjab. The lure of getting better returns for their animals encourages local villagers to get rid of their poorer ones, and using the better animals, they endeavor to multiply them as fast as they can. In this way, some improvement has been effected. As more and better animals are produced, dairies in larger villages have been gradually developed. Little by little, the dairies have extended to the cities; and to-day we find many regularly organized dairies in the cities of India supplied regularly with animals produced, not only in Sind and the Punjab, but also in other places.

Dairying in cities

Estimates made by a number of men in the dairy business place the number of dairy cows within the confines of the city of Bombay at from sixty to seventy thousand. Only about 6,500 of this number are regular cows; the remaining are buffaloes. The Mehsana and Murrah breeds of buffalo milch cows are the most generally used on account of their relatively larger yield of milk. These animals are recruited from the states of the Punjab and Gujerat. The Kathiawar cattle are the most commonly preferred. Sind cows, crossbred Kathiawar × Ayrshire, and Sind × Ayrshire are also found; but the crossbreeds are growing less in popularity, owing to the fact that they are very delicate animals and, like the pure breeds of Eng-

[13] Banergee, B. N., and coworkers. (1936–1937). Vitamin A assay of ghee, parts I, II, III, IV and V, Agriculture and Live Stock of India. vol. VI and VII.

lish and Australian dairy cows, they have been found unsuitable to the climate in Bombay. The Kathiawar cows present head characteristics very similar to those of Gir cows, namely, buffalo-shaped forehead and horns which curve like those of the ram. The prevailing colors are light red, but many are spotted.

The writer had the privilege of visiting one of the largest dairy farms in Fort Bombay located at Jacob's Circle. This farm is said to be twenty-five years old. At the time of this visit, there were 300 cows actually in milk, 260 of which were buffaloes. The remaining 40 were regular cows. More than one-half of the buffalo cows belonged to the Mehsana breed, and the rest were Murrah. With the exception of one crossbreed Ayrshire-Sind cow, all the regular cows were Kathiawar.

The amount of milk yielded daily by these 300 cows in the dairy farm, at the time of this visit, was 5,089 pounds (2,310 liters). Some Mehsana cows, according to the manager, produce 25 pounds (10 liters) per day at the height of their lactation. The milk from this dairy tests, on the average, from 7 to 8 per cent butter fat.

All the animals in this dairy, including their calves, were crowded into a space of about 100 by 200 meters wherein stood four long and roomy double barns with no stanchions at all. The animals were tied to rings in rows and not much movement of the animals was possible. Milking was done twice daily, at about 3 a. m. and at 4 p. m. The animals were taken to troughs about fifty meters from where they were tied and bathed there. This was about the only exercise the animals had during their stay on the farm.

No green feeds were given. The manager was kind enough to give the list of daily feed consumption for 250 cows, as follows:

KINDS OF FEED	QUANTITIES		TOTAL AMOUNT OF FEED	
			lbs.	*kgm.*
Cotton seed meal	5 bags each	5 maunds each *	1,000	454.5
Chuni gram	10 " "	6 " "	2,400	1,090.9
Rice bran	5 " "	5 " "	1,000	454.5
Coconut cake	2 " "	6 " "	480	218.2
Gram husks	20 " "	1.5 " "	1,200	545.5
Native hay **	25 bales "	5 " "	5,000	2,272.7

* The maund used in buying these feeds, according to the manager of the dairy, weighs 40 lbs.

** Sample of this hay was sent by Dr. V. Villegas to Dr. Eduardo Quisumbing, Bureau of Science, who identified the plant as *Themeda triandra* Forsk. In the letter which he sent to Dr. Villegas, Dr. Quisumbing stated that this grass abounds in Central Luzon, and that in Camp Stotsenburg the grass is used for feeding livestock.

Under such a method of management, the dairy buffalo cows improved in condition but lost much of the hair on their bodies. The long dense hair, however, of the Mehsana buffaloes remained, and in some cases they had to be clipped close to the skin to make them look a bit different from some of the equine species.

No attempt whatsoever is made to rear the calves. Since their presence is required to stimulate the milk flow of their mothers, they are fed just sufficient to keep body and soul together. They are all very thin. Strangely enough, disease has not given the dairy any problem whatsoever. No veterinarian is employed to take care of the animals. Such ailments as wounds or ordinary diarrhoea are attended to by practical men. Diseases are few and far between.

When the cows go dry, they are sent out to their pastures about fifteen miles out of town. They are bred there. If conditions do not improve, they are disposed of for beef. Replacement of dairy animals has not given the dairy any trouble, inasmuch as dairy animals can be obtained from the Punjab, Gujerat, or Sind on short notice.

Only a few years back the European population in Bombay would never use fresh milk owing to the unsanitary conditions under which milk was produced. However, since the Parisian Dairy Products, Ltd., has put up a plant for pasteurizing milk, the consumption of fresh milk has increased enormously.

In the well-equipped modern dairies in Calcutta, regular cows exceed the buffaloes in number. The total number of cows used for dairy in Calcutta could not be ascertained. However, the writer had the impression that there were more dairies in Calcutta and more dairy animals than in any other city in India.

Organized in 1897, the Aligarh Dairy Farm in Calcutta, owned by Edward Keventer Dairy Co., Ltd., is one of the oldest among private dairies in India. The company enjoys the distinction of owning dairy farms in all the cities from Lyallpur, Punjab State, to Calcutta, Bengal, passing through an unbroken chain of clean, up-to-date dairies in the United Provinces. The total number of cows actually in milk in all their dairies is not less than 2,000 at a time.

The Aligarh Dairy Farm in Calcutta is located at Ballygunge four miles out of the city. At the time of this visit there were 135 cows in the milking herd nearly all of which belonged to the Hissar breed. One cow, a Multani, stood out prominently owing to her red color as the Hissars are silver gray. There was not a single purebred or crossbred dairy cow in this herd. The average yield of these cows is about 12 pounds (5.5 liters) a day during lactation.

The manner in which Edward Keventer Dairy Co. recruits its supply of dairy cows is along the same line as that employed by the Parisian Dairy in Bombay; that is, by buying them from the open market in the Punjab. No attempt is made to raise the calves born out of the cows in the dairy herds. They are fed as little as possible. As soon as they are large enough, they are disposed of for veal or sold for about 5 rupees each, equivalent to ₱3.75. Under conditions obtaining in Calcutta, the cost of raising calves up to the time of freshening has been estimated at about 300 rupees. Good heifer cows of the Hissar or Sahiwal breed can be obtained in the Punjab cattle markets at half that amount. The principal cattle markets in the Punjab State are: Amritsar, Jahazagarh, Kulu, Shah, Hissar, among others.

On account of its proximity to the city of Calcutta, the Aligarh Farm has been forced to get along on a rather limited space of ground. Nearly all the land of the farm is used for the planting of soilage grasses, such as Napier, jowar, sorghum, and Guinea. Dung manuring maintains fertility of the soil, and the production of soilage is rather high—10 tons to the acre even during the dry season. Silage is used throughout the entire year and rice straw passed through a cutter makes excellent cattle feed when mixed with freshly cut green grasses. The concentrate feed given the milking cows consists of crushed gram, 1 part; linseed oil meal, 1 part; and wheat bran, 2 parts. Each animal receives 10 pounds of the mixture every day regardless of weight and the amount of milk yield. A sufficient amount of molasses is added to the mixture just to moisten it at the time of feeding. Milking is done three times daily. The time spent in labor due to extra milking is compensated by the low incidence of udder troubles and the relatively higher amounts of milk obtained.

THE INFLUENCE OF CLIMATE UPON THE EUROPEAN BREEDS OF DAIRY CATTLE IN INDIA

It is a matter of general knowledge that dairy cattle have been brought over into India from the British Isles during the last hundred years, and, beginning the year 1886, the Imperial Government of India established regular dairy farms in cantonments at various places in India for the purpose of supplying sanitary and wholesome milk to military hospitals and for use of civil servants, and in nearly all cases these military dairies were stocked with European cattle.

Expecting that there must be some regions in India where European dairy cattle would do well, private dairy enterprises were formed

from time to time. These enterprises brought into India a large number of dairy cows, not only from Europe but also from New Zealand, Australia, and the United States. No country in the world, therefore, could offer better opportunity than India for the study of the adaptability to tropical environments of the dairy breeds of cattle of temperate-climate origin, because in India nearly all types of climate exist. However, as far as the writer was able to ascertain at the time of his visit, there was not a single purebred European dairy cow in the hands of Indian villagers. These cows were said

A map of India. Places visited indicated by asterisks. (Courtesy of the Manager of Publications, Delhi)

to be found in regularly organized dairies, research institutes, agricultural schools and colleges, and in the many dairies of the Military Government. Many of these dairy farms were visited and the experience of the people who have handled the European breeds of dairy cattle therein as well as those of their predecessors may be found in the notes which the writer took during his visit. These dairy farms have a fairly wide range of distribution in India as may be seen in the map.

CEYLON GOVERNMENT MILITARY DAIRY

The land dedicated to this dairy comprises an area of 120 acres (48.5 hectares) much of which is rolling land. Adequate irrigation facilities are available for the lower level areas on which the planting of soilage crops, such as Guinea grass, Napier, Gautemala, and Mauritius, is made regularly. Low and well built barns roofed with red tile neatly constructed on the elevated portions of the farm make it look more like a residential place than a dairy farm. The total number of animals of this farm at the time of this visit was 305, of which 103 were actually in milk. The amount of milk produced in one day was 280 quarts, equivalent to about 268 liters. The main purpose of the farm is the production of wholesome milk for use in government hospitals at Colombo. Many small private dairies stocked with Indian buffalo cows have been in operation in Ceylon, but the unsanitary way in which milk is produced in these dairies has made it necessary for the government to run a dairy under its own control.

The majority of the cows on this farm were crossbreeds from Red Scindi cows and Ayrshire bulls. There were three Ayrshire bulls used for stud purposes and only one purebred Ayrshire cow. In the herd were 12 purebred Red Scindi cows, 1 Red Scindi bull, and many young ones. Only one other breed was found, namely, the Hissar. Data on milk yields from Ayrshire cows on the year immediately following their arrival from England were to the effect that they were much lower when compared with the records of cows kept under similar circumstances in their place of origin. Ayrshires have been found delicate, and even when given the best of care, it has been rather difficult to maintain them in condition. They become easy victims of heatstroke, foot-and-mouth disease, red-water, otherwise known as piroplasmosis, and at times some die from unknown causes.

According to the manager of the dairy, the history of the Ayrshire cow referred to above is typical of the many Ayrshire cows brought into Ceylon, whether it be from the British Isles, Australia, or New Zealand. She was born from a newly imported British cow and was raised in the up country in Ceylon, in a government-owned dairy at Nanuoya, elevation about 5,500 feet above sea level. Up in that region the calf developed fairly well when compared with other calves raised side by side with her. She was brought down to the Narahenpita Dairy to be bred to the purebred Ayrshire bull in that

dairy. All was well until her first calf was born. From that time on she gradually lost condition. The writer wanted to get a picture of this cow, but the manager said that being a government employee he could be censured for allowing a photograph taken of the Imperial Government's poorest dairy animals.

PASUMALAI DAIRY

For two days the writer looked in vain for schools or a college where animal husbandry forms a part of the curriculum. It was in the American College at Madura where he was able to secure the information that the Department of Agriculture of the Madras Presidency is represented in Madura by a deputy in agriculture whose work is advisory. In the discharge of his duties he is dependent upon the Madras Presidency College of Agriculture located at Coimbatore, 150 miles away. Fortunately, the American Mission has a dairy farm at Pasumalai which can be reached by train from Madura. This dairy is run in conjunction with the Teachers' Training and High Schools. The writer visited this Dairy Farm, but finding the manager, Mr. L. L. Lorbeer, rather busy at the time, he had to go through the farm guided only by a senior high school student. The guide gave out the information that the dairy project started functioning nine years ago and that the main object was the production of milk for the school.

Good cows selected from a large number of milking cows in the locality formed the foundation stock for the dairy project. However, these cows were found to give so little milk that the idea of using native cows born and raised in Madura had to be given up as hopeless. The best Madura cows would average just a little better than one measure [14] of milk a day during a short period of lactation. Purebred Ayrshires were introduced. But after a time this breed of dairy cattle was found unsuitable to the hot moist climate prevailing in Pasumalai. The animals panted most pitifully even when placed in the shade. The majority were short-lived. Five years ago, two Red Scindi bulls were brought to the Farm; one was obtained from Karachi and the other from Madras. These bulls were mated with the best native cows as well as to the Ayrshire cows still remaining on the farm. There were nine crossbred Ayrshire-Scindi on the farm at the time of this visit, of which five were in milk. The average daily milk yield of these crossbreeds was about 3½ measures,

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[14] A *measure* is a local term used around Madura, equivalent to one *seer* in the northern states; this is about 1 quart.

equivalent to 3.4 liters, and the lactation period was about nine months. The farm also uses water buffaloes for milking purposes, but, as the local buffaloes are too small and extremely poor milkers, the introduction of the Delhi types had to be resorted to. Delhi buffalo cows, otherwise known in Madura as Murrah, have given very satisfactory results.

IMPERIAL DAIRY INSTITUTE

The Farm of the Imperial Dairy Institute at Bangalore Cantonment is ideally located on an elevated portion of land containing 120 acres (48.5 hectares). It had previously been run by the Military Department, but in 1921 the farm was turned over to the Imperial Government of India. The total number of animals on the farm was 400, of which number 80 were Red Scindi cattle, 50 were Murrah buffaloes, and 30 were Gir and Hariana cattle. The remaining animals were crossbreds containing different proportions of the blood of Ayrshire and Holstein-Friesian cattle. There was only one purebred European ox, an Ayrshire bull. The number of cows (water buffalo and regular cows) actually in milk was 150, and the daily production of the herd was about 1,500 lbs. (681 liters). Milking was done twice every day, at 4:00 a. m., and 3:00 p. m.

For years, only Ayrshire and Holstein-Friesian cows had been reared on this farm. Although Bangalore Cantonment is at an elevation of about 3,000 feet above sea level, and, on the whole, the climate is wholesome, except during the summer months of March, April, and May, nevertheless, it has been found rather difficult to maintain the Ayrshire and Holstein cows in fair condition. In the summer months their records of production invariably were low. These animals become easy victims of local diseases. Rinderpest wiped them off totally at times and re-introductions of new stock have had to be resorted to. When rinderpest had been controlled, [15, 16, 17, 18] they succumbed to other diseases. Parasitic infestations

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[15] Rahim-ud-din, Muhamed. (1936). Rinderpest immunization at Livestock Research Station Hosur Cattle Farm. The Indian Veterinary Journal 13 (2): 1-3.

[16] Anonymous. (1936). Annual report of the Imperial Council of Agricultural Research for 1935-1936. Published by the Manager of Publications. Delhi, India.

[17] Anonymous. (1937). Proceedings of the Animal Husbandry Research Workers' Conference Held in New Delhi from the 17th to the 19th February, 1936. Printed by the Manager, Government of India Press. New Delhi, India.

[18] The experimental work on the value of goat's blood in attenuating rinderpest virus was first done at Muktesar Veterinary Research Laboratory. Systematic tests of the valué of goat virus in the control of rinderpest were conducted under field conditions since replications and checks have verified the finding in

were common and accepted medications against parasitism seemed to be ineffective. On the other hand, the improved breeds of Indian dairy cattle kept side by side with them have not been greatly affected by these troubles. Crossbreeding was resorted to as a matter of necessity, and Ayrshire with Hariana was the first cross to be attempted.

Reaching the first unit of dairy barns, of which the Institute had about one dozen, one comes face to face with a tablet placed on the frontage of the barn. On this tablet the following inscription may be read:

TO THE MEMORY OF
"JILL"
AYRSHIRE-HARIANA COW
BORN ON THIS FARM 18-10-1909
DIED ON THIS FARM 14-4-1929
DURING HER LIFE TIME SHE HAD 18 CALVES
AND YIELDED 154,779 LBS. MILK

What a fitting tribute to a crossbred cow! Is it to be wondered at, therefore, that crossbreeding should have been undertaken so extensively on this farm? Whatever other motives there might have been behind the work, the fact remains that at the time of this visit besides the Ayrshire-Hariana, the other crosses on the farm were: Holstein-Hariana, Holstein-Scindi, Ayrshire-Scindi, and Ayrshire-Gir. On the whole these crossbreeds have been found superior to either parent in the amount of milk which they yield. There is one fundamental difficulty, however, which has puzzled breeders for a time, namely, the maintenance of a stable proportion of the blood of the crossbreeds. Invariably the first generation crosses have had to be graded up to the European parent, and it has been the experience that as the proportion of the European blood increases beyond 75 per cent, the progeny resulting reverts to the European in constitutional weakness and propensity to disease. Then, too, the heterogeneity of the types that one gets by top-crossing soon becomes appalling.

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various places. In 1935-1936 many lakhs of cattle, including large numbers of buffaloes, were vaccinated either with goat tissue vaccine or with blood virus drawn from goats similarly infected, and the results have been uniformly successful, in controlling natural outbreaks and in conferring lasting immunity on cattle which had not been exposed to infection. The mortality following such vaccinations, including already infected animals inoculated in the face of outbreaks, has amounted in the last two years to approximately 47 per 10,000 in the case of tissue vaccine, and 4 per 10,000 in the case of blood virus inoculations. Moreover, the extremely low cost of this tissue vaccine may be gauged from the fact that as many as 2,500 doses can be obtained from a single goat, while similarly 500 doses of blood virus can be obtained from a goat.

As a practical solution to the problem, a plan has been adopted whereby all the crossbreeds will eventually be eliminated in order that all the efforts can be concentrated towards the improvement of the Red Scindi and the Gir cattle. Parallel work on the improvement of the dairy buffaloes is well under way. In point of milk production these breeds, at present, are inferior to the crossbreeds. However, there are good indications that the performance of the local dairy breeds can be considerably increased by selection and culling, provided a large number of animals are available for the purpose.

CATTLE FARM OF THE IMPERIAL GOVERNMENT

This cattle farm comprises an area of 1,660 acres (672 hectares) and is located at Hosur, Madras Presidency, at an elevation of about 2,900 feet above sea level. Beginning in 1834, this farm operated as a Remount Station for horses for the Military Department, and for about 90 years the British Government kept on the average not less than 5,000 horses on this farm. In 1924, owing to changes in government policy, the farm was converted into a cattle farm, the objects of which are: (1) the breeding of Kangayam cattle; (2) the breeding of Scindi cattle; (3) the breeding of crossbreed milch cattle for the Coimbatore dairy and bulls for breeding in Madras and Hills, and for the experimental herd of Bangalore cattle; and (4) the breeding of Ongole cattle until the farm is fully stocked with Kangayam, Scindi, and crossbred cattle, and until the Ongole Livestock Research Station at Chintaladevi is ready to take the Ongole cattle over.[19]

The present director of this cattle farm, Captain R. W. Littlewood, has had fifteen years' experience in animal husbandry work in India. Along with the Indian dairy breeds, the present cattle farm of the Imperial Government was started in 1924 with a number of Ayrshires; and the writer was informed that by 1930 no purebred Ayrshires were to be found on the farm. The director stated to the writer that "South India is not the place for animals of temperate-climate origin." Their offspring are greatly reduced in size; they suffer severely from foot-and-mouth disease and other ailments; and it is not economical to raise them. Even if they can be given the best of care and management, they eventually eliminate themselves. Animals graded up to them suffer the same fate as their purebred par-

[19] For further detail regarding this work refer to the Report of the work of the Agricultural Stations in the Madras Presidency for the year 1935-1936. Printed by the Superintendent, Government Press. Mount Road, Madras.

ents. The F 1's are fearfully cow-hocked and are subject to bone troubles. Capt. Littlewood's views on the question of animal breeding for the tropics are expressed in his recent book, entitled Live Stock of Southern India. He says that it would be far better to concentrate the work on the improvement of the most promising breeds of Indian cattle, and, according to him, the work can be speeded up by close inbreeding.[20]

At the time of this visit there were on the cattle farm of the Imperial Government, besides the Ongole cattle, about 303 other cattle used for dairy purposes as may be seen in the following table:

Cows in the dairy herd of the cattle farm of the Imperial Government

DESCRIPTION	COWS IN MILK	DRY COWS	N. P.* COWS	CALVES	TOTAL
Crossbreeds	11	0	1	15	27
Scindi **	42	0	10	51	103
Hallikar	13	0	5	12	30
Kangayam	59	4	17	63	143
Total	125	4	33	141	303

* N. P.—nearing parturition.

** Two kinds of Scindi cattle were on the Farm, namely, the regular Red Scindi and the White Scindi.

The production of milk of the 125 milking cows in the foregoing tabulation was about 1,00 pounds (453 liters) a day. Milking was done twice daily, at 4:30 a. m. and 4:00 p. m. In 1929-1930 the average production of the Red Scindi cows for the herd was 5.6 pounds (2.53) liters) per lactation.[21] At that time the highest yielder was a cow which gave 5,270 pounds during a lactation of 415 days, or an average of 5.7 liters a day. At the time of this visit the champion cow yielded 6,639 pounds (3,000 liters) during her third lactation, averaging 11.8 liters a day. Records of the dams of the Red Scindi bulls used for stud at the time of this visit were as follows: 4,498 pounds (2,040 liters), 5980 pounds (2,700 liters), 6,210 pounds (2,800 liters), and 6,639 pounds (3,000 liters). The milk tests from these cows averaged 3.2 per cent butter fat.

[20] Littlewood, R. W. (1936). Live-Stock of Southern India. Printed by the Superintendent, Government Press. Mount Road, Madras.

[21] See Report of the Work of the Agricultural Stations in the Madras Presidency for the year 1929-1930. Printed by the Superintendent, Government Press. Mount Road, Madras.

Every conceivable means of producing and preserving feeds has been developed on this farm, owing to the large number of animals that are raised. Forty-eight pit silos were continually operated. Guinea grass, jowar, ahd sorghum are preferred to other grasses for silage. These are just dumped into the pit silos without being passed through cutters.

IMPERIAL AGRICULTURAL RESEARCH INSTITUTE

One of the most interesting pieces of work along the line of breed improvement of Indian dairy cattle was found in the Imperial Agricultural Research Institute at New Delhi, the capital of India. This

Fig. 3.—Champion Red Scindi cow in the cattle farm of the Imperial Government at Hosur, Madras Presidency. Record of production: 3,000 liters on third lactation; 11.8 liters a day.

institute, formerly known as the Pusa Agricultural Research Institute, was located at Pusa, but an earthquake occurring in January, 1934, destroyed many plants and buildings so badly that it was decided to move it to Delhi. The Institute started operation in New Delhi in 1935 under its present name. In Pusa, under a mild temperature ranging from 60 to 89 °F (15.5 to 31.6°C) with a low relative humidity of 69 per cent and rainfall of not over 66 inches a year, it was thought that European dairy cattle would do well. But years of experience proved the contrary. Later on the grading up of the most promising Indian breeds to Ayrshire was given a trial. After

fifteen years of work of this sort, the plan was dropped entirely in order to concentrate all efforts upon the building up of a new dairy breed using some of the most promising Indian cattle as foundation stock. The Sahiwal breed, formerly called Montgomery, was selected because in 1913-1914 a herd of these cows consisting of 49 head gave an average of 5.8 pounds (2.63 liters) milk yield during a period of 44 weeks, or 307 days. Under proper methods of breeding the average milk yields of the herd improved, as may be seen in the following table:

Average milk yield of the Sahiwal dairy cattle from 1914 to 1936 at the Pusa Agricultural Research, now Imperial Agricultural Research Institute

YEARS	NUMBER OF COWS IN HERD	TOTAL DAILY PRODUCTION	DAILY AVERAGE FOR THE HERD	
		lbs.	*lbs.*	*liters*
1913-1914	49	283	5.8	2.63
1917-1918	59	401	6.8	3.08
1922-1923	47	451	9.6	4.35
1927-1928	37	460	12.6	5.71
Special handling was started beginning the year 1932 *				
1931-1932	40	545	13.6	6.17
1932-1933	42	761	18.1	8.20
1933-1934	42	769	18.3	8.30
1934-1935	32	619	19.3	8.75
1935-1936	30	632	21.1	9.56

* Special handling included, among others, (1) early training, (2) four-time milking of cows, and (3) pre-milking and handling. Scientific reports of the Imperial Institute of Agricultural Research, Pusa, for 1934-1935. Published by the Manager of Publications, Delhi, 1936.

At the time of this visit there was not a single cow in the herd of the Sahiwal dairy cattle yielding less than 5,000 pounds (2,260 liters) in 307 days or 44 weeks of lactation. The average for the herd for 1936 was well above 6,500 pounds (2,948 liters). One cow had already exceeded 10,000 pounds (4,536 liters) in 44 weeks, and the records indicated that the daughters of this cow could surpass the performance of their dam. According to the specialist in charge of this piece of work, Mr. Wynne Sayer, the performance of the Sahiwal breed of dairy cattle exceeded his expectations, but in animal husbandry, as in other work requiring time to achieve results, planning of the work and execution of the details of the plan are what counts. Referring now to the Sahiwal, he said that if his plans

can be continued the possibilities of establishing a herd of Sahiwal of not less than 10,000 pound-cows (4,536 liters) should be achieved within the next five years.

Going through the herd of the Sahiwal cattle consisting of about 178 head, the writer noticed that the animals presented a fairly wide assortment of colors. The eight bulls used actively for breeding presented eight different shades of color from almost black and deep red, to almost white and silver gray. Most of the cows and heifers were light red, differing only in degree. To the question as to whether the color differences did not bother him, Mr. Sayer

Fig. 4.—Sahiwal cow in the Imperial Agricultural Research Institute, New Delhi. Age when photograph was taken: 6 years and two months. Record of best lactation: 4,153 liters in 304 days. (Courtesy of Wynne Sayer, Esq.)

promptly answered: "Not in the least, that can be easily fixed later on." Mr. Sayer attributes his success in raising the production of the Sahiwal to three major points; namely, (1) selection of the foundation stock; (2) proper methods of breeding; and (3) special handling of the calves and later on the heifers and cows.[22]

Two principal lines of work are being pursued in connection with the Sahiwal dairy cattle; namely, the production of a vigorous

[22] Some details on this point (3) are given in the report of the Director of the Imperial Institute of Agricultural Research, Pusa, for 1934-1935. Published by the Manager of Publications, Delhi, Civil Lines, 1936.

type that is high yielding and at the same time easy feeder, in contrast to the delicate and typically European dairy type. The other is the production of early maturing type of cows that can be bred when about fifteen months of age. In both these lines of work, much progress has already been achieved.

THE CAWNPORE AGRICULTURAL COLLEGE

Making his way through intense heat, 117°F (47.2°C), on a tonga, the writer reached the Cawnpore Agricultural College about four miles from the city. It was exactly 3:30 o'clock when the writer

Fig. 5.—Sahiwal bull in the Imperial Agricultural Research Institute, New Delhi. Weight at 1 year and 11months of age, 403 kgm. (Courtesy of Wynne Sayer, Esq.)

and Mr. Alam Singh, in charge of the dairy, got to the barn to see the cows milked. Strangely enough, although it was fearfully hot, not one of the cows showed any effect of the heat. They were feeding voraciously on the concentrates placed in front of them. Mr. Singh explained that the function of the college dairy being largely instructional, it was advisable at least in the beginning to have different kinds of milch cows. In the herd were Hissar, Red Scindi, and Sahiwal cows. The Murrah breed represented the milch buffaloes. Complete records of the production of the cows have shown decidedly the superiority of the Sahiwal cows over the Red Scindi and the Hissar

as to milk yield. Thus, the average for the herd per cow during the standard period of lactation of 44 weeks, or 307 days, for each of the breeds roughly stated were: 3,800 pounds (1,720 liters), for the Red Scindi; 3,200 pounds (1,450 liters) for the Hissar; 5,000 pounds (2,260 liters) for the Sahiwal; and 4,000 pounds (1,814 liters) for the Murrah buffaloes.

ALLAHABAD AGRICULTURAL INSTITUTE

This institute was founded in 1912 by Dr. Sam Higginbottom who came to India originally as a missionary. Finding that what India needed was not so much religion as food, he labored hard to found an institution which would harmonize both objectives. With each passing year, the Institute became more and more firmly established; and at present the Allahabad Agricultural Institute is recognized as one of the best, if not the best, agricultural school in all India.

The history of dairying in this Institute is of particular interest. At the time of forming the dairy herds no information was available as to the type and breed of milch cows that were adapted to conditions obtaining in Allahabad. As a beginning, four different kinds of milch cattle were brought to the Institute: namely, Brown Swiss, Holstein-Friesian, Jersey, and Guernsey. Later on, some Ayrshires were also brought in. Representative samples of the Indian dairy breeds, such as Red Scindi, Sahiwal, Hariana or Hissar were also brought in. The land on which the Institute stands covers an area of about 500 acres (200 hectares) wedged in between two rivers, the Jumna and the Ganges, and a fairly large number of animals can be raised thereon. As one of the objects of the work was to determine which of the different breeds already brought in would do well in the locality, all the animals were given the same care and treatment.

In time the European breeds had largely eliminated themselves by their own inability to live long. The Red Scindi, on the other hand, had increased regularly year after year; and in 1934 when stocks were taken as to what particular breed was making money for the dairy, it was found that the Red Scindi stood at the top, surpassing all other breeds. Moreover, in the crosses made between Indian and European breeds, whenever the blood of Red Scindi entered in the cross, it invariably exerted some advantage over other bloods.

In line with the idea of helping the village people in the vicinity of the Institute to produce rich milk so essential in their diet, Murrah buffaloes from Delhi were also brought to the farm. At the time of this visit the Institute's herd of oxen and water buffaloes numbered about 300, of which 70 of the cows were actually in milk. The daily production from these 70 cows was slightly in excess of 400 pounds (181 liters). The Red Scindi outnumbered any other breed, the crossbreeds coming second. Nearly all of the crossbreeds were Red Scindi crossed with either Holstein or Brown Swiss or Jersey.

About three years ago, Dr. Burch H. Schneider studied the economic aspects of the milk records of all the animals in the dairy herd. The conclusions which he drew justified the policy of concentrating the work towards the building up of the Red Scindi. As a side problem, all the promising crossbreeds are being mated back to the Red Scindi with the idea of recovering, if possible, some of the genes for milk yield possessed by the European animals. The records of the dams of the three Red Scindi bulls used for breeding merit being mentioned in this report. One bull was from a cow which in her eleven consecutive lactations averaged 5,000 pounds (2,260 liters) per lactation of ten months' duration; another was from a cow which averaged 5,600 pounds (2,540 liters) in seven consecutive lactations; and the third bull was from a cow which averaged 5,800 (2,630 liters) in seven consecutive lactations.

In the interest of animal husbandmen in the Philippines who are raising Brown Swiss, Jersey, and Holstein-Friesian cattle, it should be mentioned that while going over the various methods employed in Allahabad Agricultural Institute of preserving feeds in the form of silage in pits, the writer found three bulls representing three different breeds of European cattle; namely, Brown Swiss, Holstein-Friesian, and Jersey. One of these, according to Doctor Schneider, had been on the farm for about seven years. "You see," Doctor Schneider said, "they do not all die at once." But these animals were separated from the main herd and were not used for breeding.

ALLAHABAD GOVERNMENT MILITARY DAIRY FARM

This dairy farm is one of the oldest of its kind in India, having been organized in 1886. As in other military dairies, the foundation animals were Ayrshires. Crossbreeding Ayrshire with Indian dairy cows was practiced later. This failing, Holstein-Indian crosses

were given a trial. At the time of this visit all the cows on the farm were crossbreeds. The bull in actual use was a 3/4 Holstein-Friesian. More than one-half of the cows used for dairy were buffaloes—Murrah breed—these having been found the best suited to Allahabad conditions. Random samples of the records of the Murrah buffalo cows place their production upwards of 5,000 pounds (2,200 liters) per lactation. Exceptionally good farm bred buffalo cows averaged slightly better than 6,000 pounds (2,700 liters) in six consecutive lactations.

As the principal object of the dairy is to produce as economically as possible an adequate supply of wholesome milk for use in government hospitals and for civil servants, and having found that the cost of raising animals in the farm to the age of freshening is high, the farm adopted the practice of getting the supply of its Murrah cows directly from the cattle markets in Karachi and the Punjab State. The best buffalo cows have been obtained from Gujerat and Amritzar. Agents of the Military Department are on the spot during market days to pick out the cows which meet requirements. They must be young, preferably in their first freshening. Although the cows so obtained, on the average, yield lower than those raised on the farm, the practice is justifiable for economic reasons.

As part of the program for breed improvement, calves from high producing cows are given special care. Proper attention to feeding and grooming form a daily routine. All the animals are passed through an arsenic dip at intervals of one month. The Allahabad Government Military Dairy is probably one of the few dairies in India where no soilage crops are grown. The dairy has an extensive area of excellent pasture land whose fertility is maintained by animal manuring. Natural pasture grasses grow luxuriantly in season. Most of these grasses are ensiled in numerous pit silos or cut for hay which are preserved in huge piles. Under such a method of management, an adequate supply of feed is available the whole year round.

EUROPEAN DAIRY CATTLE IN THE NORTHERN PROVINCES

Owing to the favorable reports gathered by the writer mostly from government veterinarians in and around Delhi to the effect that the Ayrshire and Holstein-Friesian cows have done very well in the Northern Provinces, and that they are such heavy producers of milk that whenever available they are to be preferred to the Indian breeds, special effort was made to visit every dairy in which

these are supposed to be found. Unfortunately, however, this effort proved unavailing. One of the private dairies visited, the Edward Keventer Company, Ltd., at Delhi, which according to information, contains the largest number of Ayrshire and Holstein cows, had only one purebred Ayshire bull. The majority of the 70 odd milch cows were first-generation crosses between Ayrshire and Sahiwal.

It was the good fortune of the writer to have met an English gentleman who had been in the dairy farming business in the state of Punjab during the last twenty years. He relates that during his first few years in the business he raised only Ayrshires and Holstein-Friesians. For a time the animals did very well, and their production was high. Then one year an outbreak of foot-and-mouth disease killed off nearly fifty per cent of his animals. Those which survived the infection were rendered practically worthless as sources of milk. With some hope of success, he graded some Sahiwal cows up to the Ayrshires and Holsteins, attempting to raise the European blood of the grades by top-crossing. By the time he had many ¾ and some ⅞ grades on the farm, another outbreak of foot-and-mouth occurred and the losses which he sustained were appalling. One attack of foot-and-mouth did not seem to protect some of his animals from further attack.[23] Thereafter, whenever any disease broke out in the locality, the purebred European cattle and the high grades were almost always sure to be easy victims. Local breeds kept side by side with them did not catch the disease or got only a slight touch of it and their milk production did not even suffer.

The gentleman referred to above has travelled throughout India of late, and to him the information is due that "there are not more than a couple of dozen purebred European dairy cattle in all India at present, and most of these are in the dairies of the Military Department." During the summer months, when the offices of the Imperial Government are moved to the Hills,[24] the dairy animals are moved with them. Private dairies run by Europeans still keep some bulls solely for the purpose of crossbreeding and not for propagation as purebreeds. The temperate climate of certain portions of northern India, no doubt, is more conducive to the promotion of bet-

[23] Researches on foot-and-mouth disease at Muktesar have led to the conclusion that there are, in India, at least 43 different kinds of foot-and-mouth disease, and that immunity to one kind does not render immunity to another.

[24] The summer capital of India is located at Simla Hills; Nainital is the summer capital of the United Provinces.

ter health of the European dairy cattle than the hot moist climate of the southern part. But while they can live in the climate of the northern part of India, they lacked resistance against local diseases.

GENERAL CONCLUSIONS

For some time now the writer has been engaged in the study of the adaptability of foreign breeds of cattle to the Philippines. In a paper which he read at the Twelfth Initiation Exercises of the Philippine Society for the Advancement of Research [25] on March 10, 1937, drawing conclusions from the work on the subject by Gonzalez in the Philippines (1923 and 1926), Davidson in the United States (1927), Hammond on the islands of Jamaica and Trinidad (1932), Du Toit and Bischop in South Africa (1934), Rhoad in Brazil (1936), and Yamane and Ono in Formosa (1936), the statement was made that cattle of temperate climate origin are unsuitable for propagation in the Philippines.

In his lectures on the subject of animal breeding for the Philippines, delivered in March, 1937, at the Bureau of Animal Industry, Professor F. B. Morrison stated that he could not concede that it should not be possible to adapt some of the dairy breeds of cattle from America in certain regions of the Philippines. Before making this statement, Professor Morrison had spent about four weeks in the Philippines, having been invited by the Department of Agriculture and Commerce of the Commonwealth Government to advise the Bureau of Animal Industry on matters pertaining to the raising of livestook.

The data now presented in the present paper as regards the lack of adaptability of the European dairy cattle in India, together with those previously mentioned, cover practically every tropical region in the world. These data are conclusive in showing that further experimentation on the subject of adapting cattle from temperate countries into the Philippines is unnecessary.

It would seem to be the better judgment to take the experiences in other countries having similar climate as the Philippines as a guide in our work on animal breeding. These experiences show the tremendous advantage of developing and improving such types and breeds of animals as have already become adapted to the country. If we must look for distant pastures, the most distant are not always the best.

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[25] Manresa, Miguel. The influence of temperature upon the different breeds of dairy cattle in the tropics. (Unpublished).

India offers a number of other types and breeds of live stock which have not as yet reached our shores. One would almost be tempted to suggest the bringing over into the Philippines of such dairy breeds of cattle from India as the Sahiwal and the Hissar, and of the milch water buffaloes, the Mehsana or Kathiawar. But in the Philippines we already have some of India's best; namely, the Red Scindi cows and Murrah water buffaloes for dairy and the Nellore for beef-draft. Most of these animals may be found in Government live stock farms, as well as in many privately owned farms.

In the management of cattle in India, training receives particular attention from the day the calves are born. Constant handling of the calves enables detection of their defects and vices the correction of which has become among Indians almost a subconscious act. The art of kicking, so well developed in cattle in the Philippines, is unknown among Indian cattle, and largely because of early training to which every animal is subjected.

The system of training and management reported in this paper seems to be particularly suited for the animals imported from India. It is possible that with the adoption of that system we may be able to obtain the highest possible development of the inherent capacities of the animals, even in the Philippine environment. This contention is borne out by our experiences in the College of Agriculture.

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TRIAL MANUFACTURE OF CIGARETTE, CHEWING, AND PIPE TOBACCOS FROM VARIETIES GROWN ON THE COLLEGE OF AGRICULTURE FARM [1]

EULALIO P. BALTAZAR
Of the Department of Agronomy

Every year large quantities of chewing, pipe, cigarette, Turkish, and other aromatic tobaccos are imported into the Philippine Islands. In 1935, according to the 1936 Annual Report of the Insular Collector of Customs, the Islands imported ₱5,252,067.00 worth of aromatic tobaccos. The Turkish and other aromatic leaf tobaccos are used for the manufacture of bright aromatic cigarettes by the leading cigar and cigarette factories of Manila.

In order to check the large importations of cigarette, pipe, and chewing tobaccos, the crop should be grown in the Philippines and manufactured locally into a variety of different commercial products, such as pipe, roll, snuff, cut, chewing, and plug tobaccos. The prospect of manufacturing chewing and pipe tobaccos in this country seems to be very bright, as at present there are no local factories that make these products. The use of pipes among the younger people is fast becoming popular; hence, the production of pipe tobacco to meet the need of those people should be encouraged. On the other hand, many Moros and Ilocanos chew *mascadas*, or chewing tobaccos, in various forms that are locally made by the Manila cigar and cigarette factories. These are made like cigars in "pig-tail" form, not like the American sweetened and flavored "Star" chewing tobacco; hence the writer was encouraged to make trial tests in the manufacture of aromatic sweetened *mascada*, similar to the "Star" chewing tobacco.

Probably because the formulae for the manufacture of aromatic cigarettes, chewing, and pipe tobaccos are kept secret, the writer was unable to find published references on the above subject.

Objects of the present work

The objects of the present work were (*a*) to determine which of a number of imported aromatic tobacco varieties are best suited for the manufacture of aromatic cigarette, chewing, or pipe tobacco,

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[1] Read in the Fourth Philippine Science Convention on February 24, 1937. Experiment Station contribution No. 1185.

(*b*) to find a formula for the sweetening and flavoring of tobacco for chewing and smoking purposes, and (*c*) to ascertain which of the flavors on the market are best suited for the manufacture of a given specific tobacco product.

Time and place of the present work

This study was conducted in the tobacco and cotton laboratory of the Agronomy Department, College of Agriculture, from March, 1933, to February, 1937.

MATERIALS AND METHODS

Varieties used

The tobacco varieties used in this study are White Burley, Root-Rot-Resistant Burley, Brazilian, Improved Goldleaf, Cash, Maryland Broadleaf, Warne, Jamaica, Xanthia, and Samsun Bafra. The first eight are bright, yellow, aromatic tobaccos, and the last two, Turkish.

Harvesting

Inasmuch as this paper does not deal with tobacco growing, the subject of seed bed, seed sowing and pricking, and planting the seedlings in the field are not described herein. The leaves used in this study were harvested in March and April, 1934, by the writer's tobacco class and thesis students.

Poling

After the leaves were harvested by the students, they were dried and wilted in the shed for at least one day to make the petioles tough and pliant, so that in pushing or passing the sharpened bamboo stick through them, they would not break. The leaves were poled in such a way as to throw all of the midribs on one side and the laminae on the other with a two-centimeter space left between.

Curing

Drying. The leaves were yellowed on wooden racks in the tobacco house for eight days. After they acquired a bright yellow color, they were taken down and dried on portable racks in the sun to fix their color. When their golden hue was set, they were brought into the shed to complete the drying. It took nine weeks to dry the leaves completely and thoroughly.

In the drying, great care was exercised to make the conditions as uniform as possible. When the temperature inside the building

was too warm, the windows were opened wide to admit cool air, and when the outside air was cool and moist, they were closed.

Stripping. The completely dried leaves were stripped from the poles very early in the morning, or very late in the afternoon, when the air was cool and moist, to prevent their breaking. Tobacco leaves are always brittle when the air is dry and hot. At the time of stripping, the leaves were found to contain around 24 per cent moisture.

Bundling. As soon as the soft yellow leaves were stripped from the poles, they were carefully spread out and bundled one on top of another into uniform hands, or *manos,* of approximately 100 leaves each. Sand, standard, and top leaves of uniform color and size were bundled separately and labeled accordingly.

To preserve the fine, sweet, volatile aroma of tobacco, the writer found that the best method in storing and aging it is to put the *manos* into a box about 65 centimeters high, 75 wide, and 100 long. The inside of the box is first lined with heavy Manila paper and then with a layer of oiled or paraffin paper. The tobacco is pressed down hard and covered with oiled and thick Manila paper. A removable cover is placed over the top of the box so that the contents may be examined from time to time for any change or damage made by pole burn, stem rot, or tobacco beetle.

Fermentation or sweating

Generally, sweating removes the harsh, bitter, and raw taste of leaf tobaccos and improves and developes the flavor and aroma of the leaves. During the sweating process, the green color disappears, the weight becomes lighter, and part of the nicotine content vanishes.

There are three common methods of sweating tobacco leaves, namely, natural, force, and bulk. In this study, natural sweating, which consisted of packing the leaves very tightly in wooden cases, was used. The leaves contained about 24 per cent moisture when they were packed tightly in wooden cases. The piles in the boxes were broken once a month, remade, and those leaves that were inside were put outside. When they became brittle and very dry, they were put on the floor of the curing shed at night until they became soft and moist the following day. After they had absorbed sufficient moisture, they were repacked in the wooden cases. This was continued for more than three years until they were made into cigarette, chewing, and pipe tobaccos.

Preparation of chemical solutions

Tamarind juice. Semi-ripe fruit of tamarind was boiled. The liquid in which it was boiled was strained through a piece of cheese cloth and then put into a well sealed mason jar.

Acetic acid. Five ml. of concentrated acetic acid were added to 95 ml. of water, making 100 ml. of solution with a concentration of 5 per cent.

Sodium chloride. One per cent solution was prepared by dissolving one gram of the chemical in 99 ml. of water.

Potassium chlorate. One per cent solution was made by dissolving one gram of the powder in 99 ml. of water.

Sodium nitrate. One gram of the crystal was dissolved in 99 ml. of water.

Flavors used

Many different kinds of flavoring extracts were tried in this study. They were valerian, clove, nutmeg, cinnamon, vanilla, sassafras, Havana, Virginia, tonkanol, anis, rose, maple, vanillic powder, lemon, black walnut, cedar, oils of various spices, and many others. The various flavors on the markets are manufactured by secret processes.

Various kinds of sauces were used in this study. They contained the following substances:

Preparation of the sauce

SAUCE A

10 parts raisin syrup
10 parts sugar syrup
10 parts sodium chloride
5 parts ammonium chloride
5 parts potassium chlorate
5 parts tamarind juice
0.3 part oil of clove
0.3 part sassafras
0.3 part ginger

SAUCE B

10 parts peach syrup
10 parts sugar syrup
10 parts sodium chloride
5 parts potassium chlorate
2 parts acetic acid
2 parts flavor X

SAUCE C

10 parts maple syrup
2 parts lemon
1 part acetic acid
1 part alcohol
0.5 part rose flavor

SAUCE D

10 parts sugar syrup
5 parts alcohol
0.5 part valerian extract
0.5 part cinnamon
0.5 part vanilla

SAUCE E

10 parts licorice extract
10 parts valerian extract
10 parts lemon syrup
10 parts alcohol
0.5 part clove oil
0.5 part nutmeg oil
0.5 part vanilla

SAUCE F

10 parts maple syrup
10 parts alcohol
5 parts chocolate syrup
1 part Havana flavor

SAUCE G

10 parts sugar syrup
10 parts alcohol
5 parts potassium chlorate
5 parts sodium chloride
1 part acetic acid
1 part rose flavor

SAUCE H

10 parts peach syrup
10 parts chocolate syrup
5 parts alcohol
1 part Virginia flavor
1 part glycerine

SAUCE I

10 parts apricot syrup
10 parts distilled water
10 parts alcohol
1 part tonkanol
0.5 part nutmeg

SAUCE J

10 parts apricot syrup
10 parts distilled water
5 parts alcohol
5 parts sodium chloride
5 parts potassium chlorate
1 part Turkish flavor

Many other combinations were used in the preparation of sauces. A prospective manufacturer usually tries different popular combinations to suit the various tastes of the consumers.

Application of the sauce on the leaves

A given kind of sauce was sprayed on the leaves. When enough leaves were treated, they were carefully spread out, laid one on top of the other, and wrapped in paraffin or oiled paper for a period of at least forty-eight hours. After drying, they were further treated with other tobacco flavors and chemicals. The treatment depended upon the purpose for which the leaves were manufactured.

Application of tobacco flavors

Method No. 1. For leaf tobacco, the flavoring extract, for example, "black walnut", was dissolved in 30 parts of water. The prepared solution was sprinkled over the leaves sufficiently to moisten them. Then the leaves were packed tightly in an air-tight container for at least 48 hours, after which they were air dried and then manufactured into cigarette filler, pipe, or chewing tobacco.

Method No. 2. For diced tobacco, the flavor was dissolved in 15 parts of a mixture of alcohol or rum and water. The prepared liquid was sprinkled over the cut tobacco which was then thoroughly mixed in a case and allowed to remain air-tight for a period of 30 hours. The diced tobacco was air-dried and worked out according to the purpose for which it was intended.

The manufacture of cigarette

Cigarettes of the best quality are usually made of tobacco that has been aged for years. The leaves are carefully selected for their color, aroma, and burning quality. Unlike cigar tobaccos, the leaves are not fermented.

After the leaves used in this study had been carefully selected, they were then moistened and dried, cut into shreds, and finally treated with highly flavored liquids. Before the shreds were treated chemically, they were sieved with a wire or bamboo sieve to remove the dust and other fine foreign materials. They were then moistened with

spirits or highly sweetened and flavored liquids, prepared according to formula, and put in an air-tight tin for at least 24 hours. They were air-dried or heated in the oven until completely dry. The shreds were now treated with flavors, such as tonkanol, Turkish, Havana, rose, maple, lemon, etc. The flavor was mixed with from 20 to 25 parts of distilled water, or with any kind of rum or spirit. The flavored shreds were put again in an air-tight tin for at least 30 hours; then dried and worked out, according to the use for which it was intended. The finished product was now ready to be rolled into cigarettes and then packed neatly in moisture-proof cellophane paper or in an air-tight tin.

The manufacture of chewing tobacco

The leaves were first moistened with water for about 24 hours to distribute the moisture evenly. The midribs or stems were then removed, and the stemless leaves were air-dried for some time. The sauce was then sprinkled over them. They were again air-dried and later dipped in a vat filled with flavoring liquids. After they had been completely saturated with the flavored and sweetened liquid, they were pressed so as to drive the surplus liquid into a vat. The leaves were then heated in the oven for some time until they became thoroughly dry. They were then again slightly sprinkled with the sweetened and flavored liquid and packed together, using a hydraulic press. The pressed tobacco now in the form of a hard cake was cut to size and then wrapped with moisture-proof cellophane paper to prevent its becoming moldy.

Manufacture of pipe tobacco

Like those of chewing tobacco, the leaves were first moistened with water, stemmed, and cut into flakes. These were granulated and then air-dried for some time. The granulated tobacco was sieved with a wire or bamboo sieve to remove the dust and fine particles. It was then moistened with spirits or liquids, prepared according to formula, and put in an air-tight container for at least 30 hours. The chemically treated tobacco was heated in the oven until completely dry. Certain flavors were then added, such as Virginia, Havana, Turkish, tonkanol, rose, black walnut, nutmeg, vanilla, cinnamon, lemon, etc. The flavor was mixed with 20 parts of water or with any kind of rum or alcohol. After the granulated tobacco had been flavored, it was put in an air-tight container for at least 48 hours, then dried and worked out as usual, depending upon the use for which it was intended. The finished product was

then ready to be packed in an air-tight tin, stored and aged for some time until it was ready to be smoked.

EXPERIMENTAL RESULTS

The quality tests, such as color, taste, burning power, aroma, and flavor of the different varieties of tobacco studied were determined by the Manager of the Alhambra Cigar and Cigarette Manufacturing Company. The results of the tests are shown in tables 1 to 5.

Table 1 shows the characteristics of the fermented leaves of the different varieties of tobacco tried in this study.

Table 2 shows the characteristics of the fermented leaves of the tobacco varieties tried after the leaves have been treated chemically.

Table 3 shows the specific use of the tobacco varieties tested after their leaves have been sweetened and flavored.

Table 4 shows the specific use of the different sauces tried in this study.

Table 5 shows the specific use of the different flavors tried in this investigation.

DISCUSSION OF RESULTS

It is seen in table 1 that tobacco varieties differ in their quality characteristics even though grown at the same time and in the same place. The White Burley variety, Cash, and Warne were found to have a very pleasant taste, very good color, mild aroma, very good flavor, and good burning quality. The variety which was found to be very strong was Brazilian, followed by Cash and Jamaica. The mild varieties are White Burley, Root-Rot-Resistant Burley, and Maryland Broadleaf. The medium mild varieties are Warne and Improved Goldleaf. The Turkish varieties have a special kind of flavor and aroma and are used only for blending purposes.

As shown in table 2, poor tobaccos when treated with sweetened and flavored liquids improve their taste, aroma, and flavor. This is especially true of the variety Jamaica. Sweetened and flavored liquids, according to the data presented in table 2, greatly improved the taste and aroma of tobacco, and as a general rule covered the imperfections of inferior grades.

Table 3 shows the specific use of tobacco varieties after their leaves had been treated chemically. The varieties that were found good for the manufacture of cigarettes were White Burley, Root-Rot-

Resistant Burley, Cash, Xanthia, and Samsun Bafra. Those that were specially good for chewing purposes were Brazilian, Cash, Jamaica, Warne, Improved Goldleaf, and Maryland Broadleaf. Those that were good for the manufacture of pipe tobacco were White Burley, Cash, Root-Rot-Resistant Burley, and Warne.

Table 4 gives the specific use of the sauces tried in this study. Sauces C, E, and I are good for cigarette manufacture; sauces A, F, and H, for chewing purposes; and sauces B, D, E, G, and J, for pipe tobacco.

The flavors which are especially good for pipe tobacco manufacture are Virginia, vanilla, lemon, black walnut, Havana, rose, nutmeg, cinnamon, and tonkanol; those for cigarette are Virginia, lemon, black walnut, Havana, rose, honey, maple, cinnamon, and tonkanol; and those for chewing are vanilla, lemon, honey, and flavor X.

SUMMARY AND CONCLUSIONS

1. Of the varieties tried in this study, it was found that Brazilian, Cash, and Jamaica were the best for the manufacture of mascada or chewing tobacco.

2. White Burley, Root-Rot-Resistant Burley, and Warne were the best for the manufacture of pipe tobacco.

3. For cigarette manufacture, the Turkish varieties, especially when blended with White Burley and Warne, were found especially good.

4. Poor or inferior tobaccos were much improved when treated with highly sweetened and flavored liquids.

5. The best flavors for cigarettes were found to be tonkanol, rose, maple, and Havana; for chewing, honey, vanilla, and flavor X; and for pipe, tonkanol, rose, Virginia, and Havana.

6. The best sauces for cigarettes are C, E, and I; for chewing, F and H; and for pipe, B, D, and E.

COMMENTS OF PERSONS WHO TESTED PIPE TOBACCO AND CIGARETTE SAMPLES

1. Sgt. Nemesio Oban, 45th Infantry, U. S. Army

Rose pipe tobacco—"It is just as mild as the Granger, the tobacco I am smoking. Because of the newness of the "Rose," the smoker may find it different from the one he is used to smoke. But for constant use, I believe the "Rose" will serve just as good as other foreign pipe tobacco".

2. Mr. Emilio Quisumbing, chief engineer, hydraulic division, Bureau of Public Works

Rose sample of pipe tobacco—"I found it to be mild and just the kind that would appeal to pipe tobacco smokers. It compares favorably with the English pipe tobacco, "Blue kind," sold at ₱0.50 per small package."

3. Dr. Murray Bartlett, former president of the University of the Philippines

Rose pipe tobacco—"It is mild and cool with good aroma".

4. Dr. José M. Capinpin, assistant professor of agronomy, College of Agriculture

Rose pipe tobacco—"The flavor is mild and yet more satisfying than ordinary pipe tobacco".

5. Dr. Francisco M. Fronda, associate professor of poultry husbandry, College of Agriculture

Rose pipe tobacco—"The tobacco is mild, does not "bite" the tongue, and leaves a pleasant feeling in the tongue."

6. Dr. Rafael B. Espino, professor and head of the Department of Agricultural Botany, College of Agriculture

"I tried the Rose pipe tobacco once and found its taste good, burning quality much better than several of the imported brands I have tried, and rather mild."

7. Mr. Andres Aglibut, instructor in physics, U. P. R. H. S.

"I believe this compares favorably with the "Lucky" brand. If smoke is inhaled, it stings the nose, perhaps owing to the wrapping paper."

8. Mr. D. G. Miranda, 1937 graduate of the College of Agriculture

"According to my taste, it is much better than our aromatic cigarettes produced locally and even better than the Piedmont".

9. Mr. A. C. Gianzon, senior student, College of Agriculture

"According to my taste, it is just as good as any American cigarette, but it lacks mildness".

10. Mom Chao Chakrabandhu, senior student, College of Agriculture

"The aroma is good; the taste is mild, yet satisfying".

TABLE 1

Characteristics of the fermented leaves of different varieties of tobacco

VARIETIES	TASTE	COLOR	AROMA	FLAVOR	BURNING QUALITY
White Burley	very pleasant	very good	very good	very good	very good
Root-Rot-Resistant Burley	good	very good	lifeless	medium-strong	fair
Brazilian	strong	unsatisfactory	lacking	unsatisfactory	fair
Improved Gold-leaf	fair	low	lacking	bitter	fair
Cash	satisfactory	satisfactory	mild	good	good
Maryland Broadleaf	pleasant	good	mild	mild	satisfactory
Warne	very pleasant	very good	mild	strong	good
Jamaica	unpleasant	fair	unpleasant	unpleasant	mediocre
Xanthia	mild	good	lacking	somewhat bitter	poor
Samsun Bafra	mild	satisfactory	very good	mild	poor

TABLE 2

Characteristics of sweetened and flavored leaves

VARIETIES	TASTE	COLOR	AROMA	FLAVOR	BURNING QUALITY
White Burley	very pleasant	bright yellow	fine and mild	mild	good
Root-Rot-Resistant Burley	good	bright yellow	improved	rather strong	fair
Brazilian	strong	rather dark	lacking	lacking	slow burning
Improved Goldleaf	fair	uneven color	lacking	bitter	fair
Cash	fine	bright yellow	fine and mild	good	good
Maryland Broadleaf	pleasant	yellowish brown	mild	fine	good
Warne	very pleasant	very good	mild	strong	good
Jamaica	fair	medium bright yellow	improved	improved	fair
Xanthia	mild	very good	mild	strong	good
Samsun Bafra	mild	dark	improved	bitter	poor

TABLE 3

Tobacco varieties selected for specific use after leaves had been sweetened and flavored

CIGARETTE FILLER	CHEWING	PIPE
White Burley	Brazilian	White Burley
Cash	Cash	Cash
Root-Rot-Resistant Burley	Jamaica	Root-Rot-Resistant Burley
Xanthia	Improved Goldleaf	Warne
Samsun Bafra	Maryland Broadleaf	
Warne	Warne	

TABLE 4

Classification of sauces tried

CIGARETTE	CHEWING	PIPE
Sauce C	Sauce A	Sauce B
Sauce E	Sauce F	Sauce D
Sauce I	Sauce H	Sauce E
		Sauce G
		Sauce J

TABLE 5

Specific use of flavors

FLAVORS	CIGARETTE	CHEWING	PIPE
Virginia	x[1]	—	x
Vanilla	—	x	x
Lemon	x	x	x
Black walnut ...	x	—	x
Havana	x	—	x
Rose	x	—	x
Honey	x	x	—
Maple	x	—	x
Flavor X	—	x	—
Nutmeg	—	—	x
Cinnamon	x	—	x
Tonkanol	x	—	x

[1] Refers to the specific use of flavors tried in this investigation.

A REVIEW: AN ENUMERATION OF PHILIPPINE FUNGI [1, 2]

The value of the book rests on the thoroughness with which the numerous scattered lists of Philippine fungi have been searched by the author. The reviewer believes that Doctor Teodoro's book fittingly supplements "An enumeration of flowering plants" by Elmer D. Merrill, which deals exclusively with Spermatophyta.

Most of the fungi in the enumeration are represented by specimens deposited in the herbarium of the Philippine Bureau of Science at Manila and in the plant pathology herbarium of the College of Agriculture, University of the Philippines.

Only the true fungi which are generally included in the Division Eumycetes are listed in the enumeration; the Myxomycetes (slime molds) and the Schizomycetes (bacteria) are excluded.

The enumeration contains a sketch of the history of mycology and plant pathology in the Philippines. It includes a bit of the eminent botanists and mycologists who played important rôles in the development of mycology and plant pathology in the Philippines.

In a pioneering work of this kind, the author is liable to overlook a number of species, published in channels not primarily botanical. On the whole, however, the reviewer believes that the book is sufficiently inclusive. The enumeration represents more than two years' work by the author. The labor involved in its preparation may be judged from the fact that in its 585 pages, 2979 species of fungi are enumerated. These species belong to 620 genera, distributed in 68 families of 22 orders. Of the nearly three thousand species, 710 are recorded as pathogenic on Philippine crop plants; 17 species are entomogenous; one is found on eggs of fish and one is parasitic on the human ear.

In addition to the enumeration of species of fungi occurring in the Philippines, including their synonyms and their hosts, the book contains indices to fungi and hosts.

In the arrangement of the fungi into orders, families, and species, the author follows the system used by Saccardo in *Sylloge fungorum* and followed by Clemens and Shear in *The genera of fungi.*

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[1] TEODORO, NICANOR G. 1937. An enumeration of Philippine fungi. Department of Agriculture and Commerce, Commonwealth of the Philippines, Technical Bulletin 4: 1–585.

[2] General contribution No. 568. Received for publication June 22, 1937.

The major groupings of the fungi are Phycomycetes, Ascomycetes, Basidiomycetes, and Deuteromycetes.

The book is a handy, comprehensive, and indispensable guide to Philippine mycologists and plant pathologists. It should be on the reference shelf of every plant pathology laboratory and library.

The reviewer believes that Doctor Teodoro and the plant pathology section of the Bureau of Plant Industry deserve the congratulations and thanks of colleagues for the completion and publication of this creditable work.

E. F. ROLDAN
Of the Department of Plant Pathology

ABSTRACT

A comparative study of guatemala, dallis, and cahumayhumay grasses as to yield and palatability to horses. AMADO B. PAGGAO. (*Thesis presented for graduation, 1933, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 513; Experiment Station contribution No. 1156*).—The objects of this experiment were: (a) to find the comparative yields of guatemala, dallis, and cahumayhumay grasses; and (b) to determine the palatability of these plants for horses. The work was done in the Departments of Agronomy and Animal Husbandry at the Colllege of Agriculture from May 14, 1932, to February 14, 1933. Three lots were divided into three parts and each lot was planted with the three different grasses. Six ponies of Native, Arab, and American blood, in good health and of different ages, were used in conducting the palatability tests.

Two plantings in furrows one meter apart and 15.24 cm. deep yielded six harvests. The plants were cultivated when they were about 30.5 cm. high, and between harvests they were cultivated twice. Harvesting took place when the grasses were 60 days old and at 60-day intervals thereafter. In harvesting the grass, care was taken not to injure the clump.

Before the horses were started on the feeding tests, they were given two days to accustom themselves to their new diet. For each test they were fed three times a day for ten days, with the fodder cut into small pieces. The grass was placed in the feed box side by side with corn fodder. Only one experimental grass was fed during each ten-day trial.

The experiment showed that the three grasses could be grown from rootstocks; cuttings of guatemala also produced good results. Guatemala forage grass was the heaviest yielder among the three, the average yield per harvest for six harvests being 14,321.46 kgm. per hectare. Second in yield was dallis, with an average production per harvest for six harvests of 9,858.43 kgm. per hectare. The poorest in production was cahumayhumay, the average yield per hectare per harvest for six harvests being 3,813.99 kgm.

With corn fodder used as the basis for comparison in the feeding trials of all the grasses, the average consumption per horse daily was 7.81 kgm. or 32.12 per cent of guatemala grass; 3.33 kgm. or 26.90 per cent of dallis; and 0.92 kgm. or 4.97 per cent of cahumayhumay.

Therefore, the three grasses studied ranked in yield and palatability in the following order: guatemala, first; dallis, second; and cahumayhumay, third.

COLLEGE AND ALUMNI NOTES

At the monthly meeting of the Los Baños Biological Club on July 29, the following papers were read:

Dr. S. M. Cendaña and Mr. A. M. Mane. Recent physical changes in Laguna de Bay and their effect on the lake fauna.

Dr. A. L. Teodoro and Mr. Jesus P. Mamisao. Corrosion of metals by motor fuel.

The Student Body officers for the first semester, 1937-38, are Isidro S. Macaspac, president; Ascario G. Tuason, vice-president; José R. Velasco, secretary; Angel G. Gallardo, treasurer; Cecilio A. Pangga, director of the College orchestra; Alfonso B. Castro and Amando E. Libunao, representatives to the University Student Council; and Lazaro A. Ocampo, representative to the board of management, *Philippine Collegian.*

During the present academic year, forty-three foreign students are enrolled at this College, 37 from Siam, 4 from China, 1 from Java, and 1 from Borneo. The lone foreign co-ed is Miss Helen Ling, from Amoy, China.

Recent additions to the faculty of the College include Mr. Manuel R. Monsalud, formerly chemist of the Paniqui Sugar Mills and, later, permit agent of the Domestic Sugar Administration; and Mr. Alfredo R. Santos, '30, Engineering, instructor in agricultural engineering, formerly with the Bureau of Public Works.

Dr. N. B. Mendiola, head of the Department of Agronomy, accompanied by his family, left for Japan on July 19. Doctor Mendiola is a member of the Philippine delegation to the seventh conference of the World Federation of Education in Tokyo from August 2 to 7.

Lieut. Ricardo Buhay, P.A. (Res.), assistant commandant in the Department of Military Science and Tactics at Los Baños, was recently promoted by the Board of Regents to the rank of assistant professor.

Mr. Andres M. Mane, '39, assistant in agricultural zoölogy, resigned on August 16 to accept a position in the fish and game administration, Bureau of Science.

The Ranchers' Club held a delightful barn dance in the Animal Husbandry compound on August 12. The Association of Junior Sugar Technologists held its annual program and dance at Molawin Hall on August 14.

About 63 per cent of the 51 articles released to the press by the U. P. Information Service during the academic year which ended May 31, 1937, were contributed by the College of Agriculture, according to a report submitted by Dr. Bernabe Africa, executive secretary of the Service.

A party of brothers from De La Salle College observed the work of the College of Agriculture on July 15. The visitors were the Reverend Brothers John, Hilary, and Lucian, and Prof. A. Buenconsejo.

Mr. En-Huan Huang, professor of Chinese literature at the University of Amoy, accompanied by Mr. Che-Yuan Huang, of the same University, were campus visitors on June 20.

Dr. Pedro A. David, assistant professor of agronomy, has been appointed by the Dean as his special representative to inspect students' dormitories and advise students on improvement of living conditions.

Of the alumni of this College who are teaching in the Bureau of Education, the following recently attended the Officers' Training School at Camp Allen, Baguio: Juan I. Neric, '21; Casimiro de Sagun, '22; Basilio Ponce, '22; Francisco Pañganiban, '24; Constantino Derecho, '27; Dimas Maulit, '28; Perfecto C. Boncato, '30; Pantaleon Dumlao, '31; Alejandro Soriano, '31; Ignacio Ang, '32; and José C. Saddul, '32.

FARM SECURITY FOR THE TENANT[1]

The situation of the share cropper today is the classic example in the Philippines of wretchedness and misery. Increasing discontent, flaring up at times in armed resistance and bloodshed, is spreading and stirring up like a leaven the hitherto inert mass of complacent peasantry. Thoughtful men from high government quarters, keenly aware of a potentially dangerous situation, are exploring the possibilities of solving permanently the problems of the share cropper.

The view is crystallizing that the ultimate solution of the tenancy problem is to establish this great body of landless peasantry as farm owners. Hence, the advocacy by responsible men in the government of the state purchase of large estates for resale to tenants. This is an alluring and worthy plan but, as outlined, its success is open to serious doubt. Prudence would dictate that a thorough study of the problems of tenancy be made before embarking on such an expensive program. The conversion of the share cropper into a freeholder is a most difficult one and, certainly, it can not be done overnight. To prove this assertion, it is necessary to examine briefly the facts surrounding the tenancy problem.

With one farm out of every five worked by tenants, the extent of tenancy in the Philippines is surprising in view of a liberal public land policy of disposing of a vast public domain. And what is worse, our studies have shown that tenancy is a fixed status and, therefore, not a step to farm ownership.

The share cropper is an unequal and helpless partner in crop production. He comes from the most ignorant class and economically the poorest. The landlord, on the other hand, belongs to a dominant group, socially, economically, and politically. A situation like this offers a fertile field for exploitation of a rapacious sort. Our study of tenancy contracts on rice farms shows by what ingenious ways of advances and interest-taking an unscrupulous landlord can dispossess the cropper of the fruits of his toil to such an extent as to bind him to the farm in a manner reminiscent of medieval Europe. The landlord has been pilloried before the public, but he is no less

[1] General contribution No. 569.

a victim of a system which is beyond his control. The ignorance, illiteracy, and poverty of the cropper are known only too well. He is shiftless and improvident to a point of sheer irresponsibility, ready to squander the equivalent of the earnings of a year's toil in a few brief days of festive merry-making, completely oblivious of his responsibilities. And this, because he looks upon his landlord as the good provider to rescue him during the long lean months before harvest. As a consequence, advances, rations, and loans are inescapable obligations of a landlord to his tenant if he is to keep his farm business going. Is it any wonder, therefore, that the landlord feels justified in assessing burdensome rates of interest in view of the great risks involved in lending to a bankrupt partner in production?

But the reasons for the poverty and misery of the share cropper have to be sought deeper in this ancient system of tenure and partnership. The average tenant holding is far too small to support even the barest mode of living. Our studies show that tenant holdings average from 2.6 to 3.4 hectares from which labor incomes are obtained averaging from ₱101 to ₱133. Without supplementary incomes, these amounts are found insufficient to maintain a tenant family at subsistence level. Operations in rice farming are highly seasonal and there are long periods (August to November) of low labor requirements when much available time can be better utilized in secondary occupations. The average cropper, however, seldom makes use of this opportunity and much time is thus frittered away in voluntary idleness.

It is, therefore, obvious that unless the share cropper undergoes a complete metamorphosis, he can not successfully take advantage of any land-purchase program of the government. His ignorance, his utter lack of thrift, and his long dependence on a landlord have so undermined his character that sudden enfranchisement will in the end only prove in vain. The cropper has to be recast first in a new mold. He should be built up to a level that will insure for him greater chances of success in owning and keeping a farm. In this task of rehabilitation, the government should take the leading rôle. Evidently, this will be a work of many, many years. One might as well realize the utter impossibility of transforming at a stroke an ignorant and irresponsible peasantry into a stable class of farm owners. Given time, however, this is not impossible. Fortunately, many countries are rich in experience with land reform, notably,

Ireland, Denmark, England, and Germany, from which lessons may be drawn for guidance in our own program.

The first task is to stabilize the tenant economically. Lease contracts should be improved and freed of vicious terms by statute regulation. Already, the enforcement this year of a share-tenancy law is a step in this direction. The government should free the cropper from the clutches of usury, not by a spasmodic apprehension and punishment of some usurers, but by a carefully laid out plan of credit reform. The tenant has sunk to such a low economic level that rehabilitation loans by a government agency are first necessary because of his inability to meet the requirements of strict banking credit. As he gains in stability, new avenues of cheap credit should be opened to him to do away forever with landlord's loans. His consequent release from dependence will further help the tenant obtain more favorable leasing arrangements. Hence, a larger holding and greater opportunities for obtaining supplementary incomes might be made available to him than heretofore.

Hand in hand with these economic measures, every effort must be made to raise the tenant to an equally higher social plane. He should be freed from his rank ignorance and illiteracy. Thrift and industry must be taught him patiently. Health conditions in rural communities must be improved and, in short, every thing should be done to make farm life happier and fuller of opportunity. Then and only then will the tenant be in a position to take advantage of a land-purchase program of the government.

It is obvious, however, that even under improved conditions not all tenants can become successful farm owners. Hence, in any plan of reselling acquired estates to them, a rigorous selection of prospective purchasers is necessary for success. Certain standards of experience, capacity, and stability, such as have been adopted in other countries, must be established for purchasers in order to prove their ability to make a success of the venture. Outright sale may even be deferred until after a trial-lease period to determine the ultimate capacity of a prospective tenant purchaser. The work need not end here. Sustained help and guidance are necessary. Every assurance to enable a purchaser to meet his payments should be provided, as, for example, a variable system of payments adjusted to crop and business conditions. And, finally, to help discourage speculation, certain limitations might be imposed on the rights of a tenant purchaser to alienate his interest in the land. These are all

proven principles in other countries, and it might be well for us to consider them.

In brief, a land-purchase program for the tenants of this country should involve carefully laid plans of rehabilitating the share cropper by building him up socially and economically to a level that will enable him to buy and keep a farm. And, once stabilized, a rigorous selection of prospective tenant purchasers on the basis of certain standards and sustained help during the period of payment are requisites to success. The government must, therefore, assume the task of leading patiently the share cropper step by step in the long and arduous climb to independent farm ownership. In the quest for a permanent solution of the tenancy problem, any measure intended to bring lightning-like results is doomed to failure.

JOSÉ E. VELMONTE
Of the Department of Agricultural Economics

LOYALTY DAY, 1937

OCTOBER 9

8:30 p.m.	Dramatics

OCTOBER 10

8:30 a.m.	Opening ceremonies
9:00 a.m.	Inauguration of Baker Memorial Hall
9:20 a.m.	Military parade
9:45 a.m.	Loyalty Day program at Baker Memorial Hall
11:00 a.m.	Meeting of the U. P. Alumni Association, Laguna Chapter
12:30 p.m.	Faculty luncheon at Molawin Hall
2:00 p.m.	Athletic games
4:30 p.m.	Inter-faculty tea at the Seniors' Social Garden
8:30 p.m.	Popular dance at the Seniors' Social Garden

STUDIES ON COCONUT OIL: II. A METHOD FOR CONVERSION INTO SOLIDS [1]

JULIAN BANZON
Of the Department of Agricultural Chemistry

WITH ONE TEXT FIGURE

While engaged in the study of thermal decomposition of coconut oil, the writer observed that one particular catalyst had the unique property of converting coconut oil into a solid crystalline mass. As given in a previous paper,[2] the mere heating of coconut oil for from

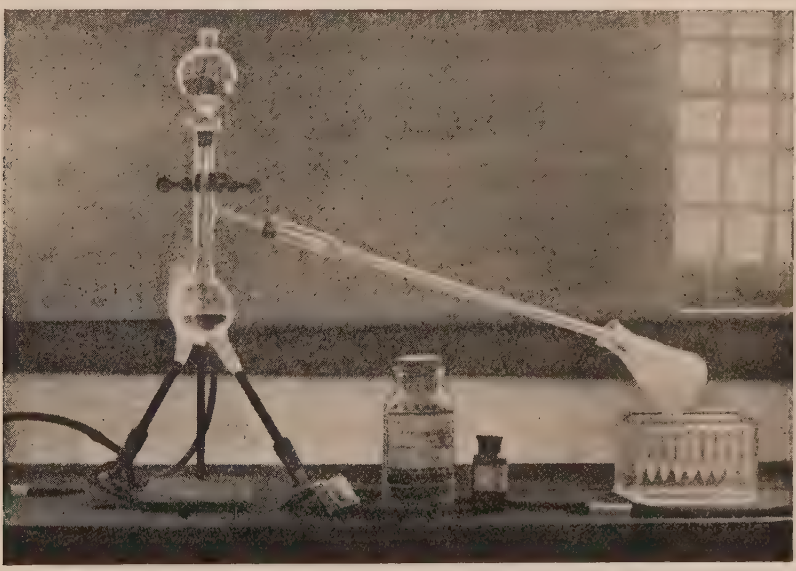

Fig. 1.—Experimental apparatus for conversion of coconut oil into solids

five to twenty hours in the neighborhood of 300°C resulted in 14 to 22 per cent conversion into a solid compound of unknown composition. The method here given attains a much higher degree of conversion at a greatly reduced reaction time. Inasmuch as the solid product is so easily produced and has properties which might be of use in

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[1] Experiment Station contribution No. 1187. Received for publication June 25, 1937.

[2] BANZON, JULIAN. 1937. Studies on coconut oil: I. Pyrolysis. Philippine Agriculturist, 25: 817-832.

the industries and as facilities do not allow its identification in the immediate future, it has been thought best to give an account of the results so far obtained.

Review of literature

A search in the literature has been made to find if the reaction of coconut oil and ferric oxide has already been recorded. No such record has been found, either for coconut oil or for any vegetable oil. Lewkowitsch (1909),[3] however, mentioned the reaction of non-volatile fatty acids (not the oil, which is composed of glycerides) and iron powder, with the formation of olefinic hydrocarbons having 22 to 28 carbon atoms in the molecule. The same author mentioned also the formation of ketones when the acids are distilled with iron. Even should the solid obtained by the method described in this paper turn out to be ketones, there is the distinct advantage of producing them direct from the oil.

THE METHOD OF PRODUCTION

Catalysts. Either ferric oxide or finely divided iron has been found to work equally well.

Procedure. The process is simple distillation with a catalyst. An ordinary 150-ml. distilling flask, preferably with low side tube, an air condenser, a receiver, and two burners are set up as in figure 1. A hundred-ml. charge of ordinary coconut oil and one gram of the catalyst are placed in the distilling flask, heated to boiling, and distillation commenced. From this point, two equally successful procedures may be employed, namely:

(*a*) *Batch process.* The first portions of distillate are liquid and are collected in a container. Soon, however, a distillate will come over which sets solid when received on a cold piece of glass. When this occurs, the receiver is changed and 40 to 50 ml. of distillate is collected. Distillation is now temporarily suspended, a 50-ml. charge of oil is added to the flask, and distillation resumed, separating the non-solidifying distillate from the solidifying portion as before. After 40 ml. have thus been distilled, the process of adding another 50-ml. charge may be repeated as desired. This method has the advantage of collecting the solid portion and removing most of the liquid portion in which the solid is partially soluble.

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[3] LEWKOWITSCH, J. 1909. Chemical technology and analysis of oils, fats and waxes, 1. xx + 542 p. London: Macmillan and Co.

(*b*) *Continuous process.* The charge of oil, instead of being added in 50-ml. portions, may be added continuously by means of a dropping funnel. The charge is made to drop as fast as distillation proceeds. Being a continuous process, it is more convenient than the batch process, but the distillate contains a larger proportion of liquids.

In both procedures, the distillation must be fast—three to four drops a second or faster. This requires two burners with flames adjusted such that they are almost smoky. Strong hissing flames induce formation of carbon which interferes so much in the heat transfer that distillation soon stops. The oil must be water-free, preferably dried at 110°C. Water causes foaming, bumping, and boiling over of the liquid. The set-up should be considered in working condition only if the distillate produced sets hard on a metal surface within a second or two. Cause of failure lies mainly in too slow rate of distillation.

The distillate thus obtained is dark yellowish, with a bluish fluorescence. It sets to a crystalline greenish yellow mass on cooling.

Purification. The crystals are separated from the liquid by suction filtration in a Büchner funnel fitted with a double layer of cheese cloth. The crystals are then scraped off the cloth, suspended in denatured alcohol, which dissolves the remaining traces of liquid, and then filtered again. Two such alcohol treatments, if done within four to five hours, yield a white mass of crystals, while four alcohol treatments result in a very white product. If the crude reaction-product is allowed to stand for more than a day, discoloration takes place which is not removed by the alcohol treatment. In such a case, dissolve the crystals in hot 95 per cent alcohol and allow the mixture to cool. A white mass of crystals is produced. Several such recrystallizations yield a perfectly white product. The purified crystals may be air-dried, giving a white crystalline powder, or melted and cast into sticks.

Properties. The purified product is a light, white, crystalline powder, tasteless, with a faint odor similar to stearic acid. It melts sharply at 55°C to a clear, transparent, colorless liquid and solidifies to a hard, rather brittle, crystalline solid. It is soluble in ether, chloroform, kerosene, and acetone; but sparingly so in cold 95 per cent ethyl alcohol. It is chemically neutral, remaining unaffected by three-hour boiling with 3N alcoholic KOH, or concentrated HNO_3

and HCl, but dissolves in concentrated H_2SO_4 to a dark liquid. It absorbs bromine in chloroform so slowly as to make the reaction appear doubtful.

Owing to its close resemblance to paraffin, this solid may possibly be used interchangeably with the latter, as for example, in candle making.

Yield. The following data give an idea of the yield from the continuous process:

RUN NO.	CHARGE		WT. RECOVERED AS DISTILLATE	RECOVERY	SOLIDS IN DISTILLATE	YIELD SOLID PER 100 GMS. OIL
	ml.	*gm.*	*gm.*	*per cent*	*per cent*	*gm.*
1	500	425	390.5	92	70	64.4
2	500	425	344.0	81	59	47.7
Average	500	425	367.3	86.5	64.5	56.0

A large amount of material which carbonizes when further heated and distilled remains in the flask. Higher conversions may be expected on a larger scale of production.

A STUDY OF THE COMPARATIVE EFFECTS OF VARIOUS MASH MIXTURES FOR LAYERS IN BATTERY LAYING CAGES [1]

FLAVIANO P. OLIVARES

Under the "egg factory" system, sometimes called the hen or laying battery system of egg production, the birds are confined indoors, in quarters utterly devoid of direct sunlight. They are not given access to any range. In view of these conditions, there is a need of supplying a ration that will furnish the food elements needed by the layers without sacrificing their efficiency as egg producers. Moreover, the ration should meet the principal requirements of the poultryman, as well as the birds, that is, be economical and at the same time effective.

From his observations on a flock consisting of 36 hens for a period of 8 months, Dr. G. Montemayor, in a letter written at Lingayen, April 8, 1935, stated that ordinary feeds for laying hens would be good in this system but they must be supplemented with green vegetables and an amount of oyster shell which should be 5 per cent more than that ordinarily given.

According to Ellenwood (1932), the discovery in late years that cod-liver oil is a remarkable substitute for sunshine has brought about great changes in poultry practice. He cited the nutrition discovery in the Wisconsin Experiment Station some ten years ago that small chicks could be kept indoors constantly if supplied daily with cod-liver oil as a part of their ration. He further stated that "the regular all-mash ration used for layers was sufficient for the needs of the caged birds."

In a mash mixture for battery layers, Arndt (1933) pointed out, among other things, the need for the presence of 1 per cent salt, 4 per cent powdered oyster shell, 1 per cent powdered charcoal, and 2 per cent cod-liver oil.

Ellis (1934) claimed that the success of the system depended mainly on feeding and culling. He always put dry mash before the

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[1] Thesis presented for graduation March, 1936, with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Experiment Station contribution No. 1188. Prepared in the Poultry Husbandry Division, Department of Animal Husbandry, under the direction of Dr. F. M. Fronda.

birds. In addition, he, at times, gave wet mash in the morning or at mid-day, but only when he had a special object in view, such as getting a hen through the molt, starting a pullet to laying, curing a broody hen (only if she had a good record), or getting an extra supply of eggs during the periods of higher prices. He gave grain at closing time during the period of short days to enable the birds to have a good reserve that would last throughout the long night; pure limestone grit was thrown into the mash troughs about twice a week, and green feed, if available and handy, about two or three times a week.

Thompson (1934) reported that a certain Captain Gregory found success in giving his battery layers dry mash feed only, without any addition of grain or of an alternative feed of wet mash. His main objection to the wet mash was that it was apt to cause mildew in the hoppers. He, however, did give shell and 2 per cent cod-liver oil.

From findings gathered by himself, Allum (1934) reported that it was very apparent that mineral feeding was best served by fish meal and meat and bone meal, to a lesser degree by cereal offals, and most poorly by green feed.

This study was conducted in order to determine a suitable ration for battery layers kept under Philippine conditions. It was begun on June 1, 1934, and closed on October 31, 1935, a period covering approximately one year and five months.

PLAN OF THE STUDY

Two trials were made in this study. The first was to study the effects of various supplements added to an all-mash-ration fed to layers confined in laying batteries. This trial was begun on June 1, 1934, and closed on March 31, 1935, covering a period of 304 days, approximately 10 months. The second trial was to compare various mash mixtures for layers confined in battery laying cages. It was begun on April 8, 1935, and closed on October 31, 1935, covering a period of 207 days, or approximately 7 months.

The laying batteries. Two separate units of laying batteries, both manufactured by M. H. Arndt & Company, were used in these studies, one with a capacity of forty-eight pullets, and a smaller one, of twelve. The batteries were in three tiers and the floor space of each cage or compartment measured approximately 40 centimeters

square. A mash hopper was available for each layer and a watering cup for every two birds was also provided. These feed and water containers were so designed by the manufacturers as to prevent feed waste and spilling of water. The wire floor of the cage was sloping to the outside so that the egg could roll out into a receptacle and thereby be protected from breakage and from being soiled.

Records

The weights of the birds were taken every month with a portable Fairbanks balance sensitive to 20 grams. The eggs laid were gathered in the afternoon. The number of eggs produced by individual layers was recorded. The amount of feed consumed by each lot weekly was also noted. A record of the mortality in each lot was kept.

EFFECTS OF VARIOUS SUPPLEMENTS ADDED TO AN ALL-MASH RATION FOR LAYERS IN BATTERY CAGES

In this trial, sixty Los Baños Cantonese pullets were used. These pullets were divided into five lots of twelve birds each. Each lot was given different supplements in addition to the mash of the College ration. This mash consisted of the following, all parts by weight: 1 part shrimp meal, 2 parts corn meal, 3 parts copra meal, and 4 parts rice bran. The nutritive ratio of this mixture, according to chemical analysis, is 1 : 3.23. The supplements added to the rations of each lot at the beginning were as follows:

Lot I—green feed
Lot II—0.5 per cent sardilene oil
Lot III—0.5 per cent sardilene oil + green feed
Lot IV—0.5 per cent sardilene oil + 1 per cent shell
Lot V—0.5 per cent cod-liver oil

In all lots, the amount of either the sardilene oil or the cod-liver oil was increased as cases of paralysis were noted. It was part of the plan to determine the minimum amount of either sardilene oil or cod-liver oil that would be necessary to add to the mash mixture used in the study.

The first case of leg-weakness was noted in lot 1 after the birds had been in the cages for 4 weeks; in lot 2, after 6 weeks; in lot 3, after 5 weeks; in lot 4, after 6 weeks; and in lot 5, after 8 weeks. The oil supplements were increased to 1 per cent in all lots, except

lot 1, after 4 weeks. As more cases of paralysis were noted, the oil supplements were increased to 1.5 per cent. After the 12 weeks of confinement, the amount of either sardilene oil or cod-liver oil that was being given in all lots, except lot 1 which was not given these supplements, was increased to 2 per cent. This amount was observed to be sufficient to prevent leg-weakness.

In most cases, the green grass used for lots 1 and 3 was obtained from lawn mowings, although occasionally, young green grass from around the laboratory was gathered and fed the birds, especially during the dry season.

The fowls were given free access to the feed and water. A point was made of changing the water daily in the morning so as to avoid fermentation of feed that might have been dropped into the cup from a bird's beak. This trouble is not possible in modern laying batteries for they are provided with drinking fountains instead of water cups.

The results obtained in this trial were summarized as follows:

For egg production, the cod-liver oil used as a supplement to rations for use by battery layers was found to be slightly better than the sardilene oil used. An addition of 2 per cent of cod-liver oil in the ration was found to be sufficient to prevent leg weakness for layers confined in battery cages.

As to the average efficiency of the supplements tested, the lot with ration supplemented with cod-liver oil proved to be the most efficient; the lot with ration supplemented with sardilene oil and shell was second in efficiency; and the lot with ration supplemented with green grass alone was third.

Inspection of the average monthly weights of the birds in all the lots reveals that they practically maintained their weights throughout the whole period of the experiment. Most of the pullets used in each lot were fairly uniform in size. They were able to keep up their weights and even increase them slightly. The average gain in weight per bird in each lot was, however, negligible.

The use of a combination of supplements in rations for battery layers seemed advantageous. From the results obtained in the experiment, there seems to be ground to state that the basal mash used was not satisfactory for laying hens confined in battery cages.

EFFECTS OF VARIOUS MASH MIXTURES FOR LAYERS IN BATTERY CAGES

Another set of sixty Los Baños Cantonese pullets were subjected to another feeding trial from April 8, 1934, to October 31, 1935. These

pullets were divided into ten lots of six birds each. The supplements used in this study were the same in all lots, but the basal mash mixtures consisted of the following, all parts by weight:

LOT NO.	FEEDS USED				NUTRITIVE RATIO[1]
	Fish meal	Corn meal	Copra meal	Rice bran	
	parts	*parts*	*parts*	*parts*	
I	2	1	3	4	1:2.07
II	2	2	2	4	1.2.22
III	2	3	1	4	1:2.49
IV	2	4	3	1	1:2.35
V	2	4	2	2	1:2.50
VI	2	4	1	3	1:2.62
VII	2	3	2	3	1:2.39
VIII	2	1	1	6	1:2.26
IX	2	6	1	1	1:2.85
X	2	5	1	2	1:2.74

[1] According to chemical analysis.

To every ration the following supplements were added:

Cod-liver oil .... 2 per cent
Powdered charcoal .... 1 " "
Salt .... 1 " "
Lakeshore sand and shell .... 6 " "
Green feed—given 3 times a week, at least 40 grams to each bird every time.

Egg production. The results obtained in this trial clearly indicate that using the egg production as the main criterion in the selection of a mash mixture for battery layers, it would be advisable to select mixture 2-5-1-2. Among the ten mash mixtures, its cost, ₱6.18 per 100 kilograms, is next to the most expensive mixture, 2-6-1-1, ₱6.39 per 100 kilograms, yet, as will be shown, its cash returns were the highest. On this basis, the only mixture that compares very favorably with 2-5-1-2 is mash mixture 2-3-2-3, considering especially the fact that the former uses two parts more corn meal than the latter.

An interesting point brought out by these results was the high tolerance among battery layers for corn. The Yellow Flint variety was used in this experiment. It was observed that neither higher than five parts by weight of corn meal in the mixture, nor lower than two parts proved conducive to egg production. It can not be denied, however, that the good results obtained from the mash mixture concerned were partly due to the supplements added. The effect on egg production of the high proportions of rice bran

to corn meal in some of the mixtures, as 2-1-3-4 and especially 2-1-1-6, was not altogether encouraging (see table 1).

To produce one dozen eggs, it was observed that lot X (2-5-1-2) required the smallest amount of feed, being only 2.14 kgm. Lot I (2-1-3-4) produced the most expensive eggs. This lot needed 3.23 kgm. of feeds to produce a dozen eggs. Based upon the prices of the feeds during the time that the experiment was being carried on, the cost of feeds needed to produce a dozen eggs varied from ₱0.19 in lots VI (2-4-1-3), VII (2-3-2-3), and X (2-5-1-4) to ₱0.25 in lots I (2-1-3-4) and III (2-3-1-4). Lots II (2-2-2-4) and V (2-4-2-2) produced eggs at ₱0.20 a dozen, lot IV (2-4-3-1) at ₱0.21, and lots VIII (2-1-1-6) and IX (2-6-1-1) at ₱0.22 (see also table 1).

Health and general tendencies of the birds. The birds kept up their weights and in spite of the confinement and the large proportion of corn meal in the lots fed with mash mixtures 2-6-1-1 and 2-5-1-2, no fattening effect was observed among the birds. In other words, the mash mixtures tested did not produce any unfavorable effect on the birds.

Generally speaking, the layers were in as good a condition at the end of the experiment as at the beginning, with the possible exception of a few birds in lots I (2-1-3-4), II (2-2-2-4), VI (2-4-1-2), and VIII (2-1-1-6) which looked rather pale and dull. The birds in the other lots, especially lots X (2-5-1-2) and VII (2-3-2-3), were apparently contented, active, and healthy looking. The toe nails of practically all the birds during the sixth month of confinement were observed to have grown fairly long. But, as was found in the first part of the experiment, no case of sore feet among the birds was noted.

The droppings of the birds in all the lots, up to the second month, were soft and in most cases watery. Later, changes in the consistency of the droppings were noted. The voidings from lots I (2-1-3-4), II (2-2-2-4), and VIII (2-1-1-6) were very much softer and oftentimes more watery than those from the other lots. This condition was probably largely due to the large amount of rice bran present in the rations of these lots. Droppings from the other lots were of normal consistency, and dark brown to black in color.

The feeding behavior of the birds was excellent in most cases. Sprinkling some water on the feed of some poor feeders, particularly the broody birds, seemed to improve their appetite. A few cases of broodiness were observed in some lots.

SUMMARY AND CONCLUSIONS

Ten different mash mixtures were compared in this study. The results obtained are summarized as follows:

1. For use in battery laying cages, mixture 2-5-1-2 (2 parts fish meal by weight; 5 corn meal; 1 copra meal; and 2 rice bran) proved to be the best among the various mash mixtures studied.

2. Taking the average of the relative efficiencies of the various mixtures based on average number of eggs, returns above cost of feed per dozen eggs, and amount of feeds to produce one dozen eggs, the ranking is as follows: Mixture 2-5-1-2, first; 2-4-1-3, second; 2-3-2-3, third; 2-4-2-2, fourth; 2-2-2-4, fifth; 2-4-3-1, sixth; 2-6-1-1, seventh; 2-1-1-6, eighth; 2-3-1-4, ninth; and 2-1-3-4, tenth.

3. Mortality in which symptoms of leg weakness were shown was observed in some of the lots. No mortality was observed among the lots fed with mixtures 2-5-1-2, 2-3-2-3, 2-2-2-4, and 2-6-1-1. The highest mortality was observed in the lot fed with mixtures 2-4-1-3, the next highest, in the lot fed with mixture 2-1-1-6.

4. The 2 per cent cod-liver oil supplement, sufficient to prevent leg weakness in birds given a 1-2-3-4 basal mash feed, was not suffiicient to prevent the disease in birds fed mash mixtures 2-1-3-4, 2-3-1-4, 2-4-3-1, 2-4-2-2, 2-4-1-3, and 2-1-1-6. It is possible that a different amount of the supplement is necessary to prevent leg weakness when these mixtures are fed.

5. Mash mixtures 2-6-1-1 and 2-5-1-2, despite the relatively larger amounts of corn meal, together with the effects of confinement, did not produce a fattening effect on the birds.

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TABLE 1

Summary of the results obtained in the use of various mash mixtures for layers in battery cages

LOT. NO.	FEED	EGG PRODUCTION [b]	AVERAGE FEED CONSUMPTION [b]	FEED TO PRODUCE 1 DOZ. EGGS	COST/KGM. FEED	MORTALITY
		per cent	*kgm.*	*kgm.*	*centavos*	*per cent*
I	2134 [a]	26.2	17.33	3.23	5.23	16.7
II	2224	32.9	12.27	2.47	5.49	0
III	2314	28.0	14.32	2.97	5.76	16.7
IV	2431	33.1	14.12	2.48	5.86	16.7
V	2422	31.1	12.78	2.39	5.92	16.7
VI	2413	34.8	13.14	2.23	5.97	50.0
VII	2323	35.6	13.75	2.24	5.70	0
VIII	2116	26.1	12.75	2.83	5.33	33.3
IX	2611	29.5	12.38	2.43	6.39	0
X	2512	37.4	13.85	2.14	6.18	0

[a] Figures refer to feed in the following order: 2 parts, by weight, fish meal, 1 corn meal, 3 copra meal, and 4 rice bran.

[b] From April 8, 1934, to October 31, 1935.

THE EFFECTS OF APPLICATION OF CERTAIN FERTILIZERS AND SOIL AMENDMENTS ON THE NUMBER OF MICRO-ORGANISMS IN NANHAYA CLAY A LOCAL ALLUVIAL SOIL [1]

D. I. AQUINO AND F. B. MAÑGAHAS

WITH THREE TEXT FIGURES

The importance of micro-organisms in the soil varies greatly with their forms and functions. The micro-organisms, bacteria, molds, and *Actinomyces* are active in attacking insoluble protein or carbohydrate molecules, or oxidizing, reducing, or hydrolyzing the numerous substances which serve as sources of energy and as materials for cell construction.

In number, bacteria are the most numerous in the soil. Some of the processes in which bacteria play an important role are ammonification, nitrification, denitrification, oxidation, nitrogen fixation, and mineralization. These processes are accompanied by bacteria with the aid of enzymes secreted by them.

Molds found in the soil are an important factor in the transformation of soil constituents. This group of organisms in the soil is very active in cellulose and carbohydrate decomposition.

Actinomyces are sometimes called ray fungi. They are also found to occur in the soil in great abundance and help in decomposing organic matter, fats, cellulose, and starch.

The influence of fertilizers and soil amendments upon the number of micro-organisms in the soil. The addition of certain fertilizers and soil amendments to the soil may tend to stimulate the activities of the micro-organisms in the soil in various ways. The physical, chemical, and biological conditions of the soil are changed. The addition of fertilizers like sulfur and ammonium sulfate which makes the soil reaction acidic was found to increase the number of fungi, but a decrease in the number of bacteria and the number of *Actinomyces* was oftentimes noted.

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[1] Part of the material in this paper was reported in a thesis presented March, 1936, by the junior author for graduation with the degree of Bachelor of Agriculture from the College of Agriculture. Thesis No. 994. Experiment Station contribution No. 1189. Received for publication April 17, 1937.

The addition of calcium carbonate, a soil amendment, to the soil tends to reduce the hydrogen-ion concentration and is followed by an increase in the number of bacteria and of *Actinomyces*.

Factors which may influence the activities of micro-organisms. Waksman (1922a) states that fertilizer treatment exerts the following effects on the number of micro-organisms: (1) Phosphates and potassium salts were found to stimulate the growth of micro-organisms; (2) The addition of lime, making the soil basic, resulted in a decrease of fungi and an increase in the number of *Actinomyces* and of bacteria; (3) Manure showed a decided stimulating effect upon all groups of micro-organisms developing on the plate.

Utzurrum [2] found that fertilizer application increased the production by the promotion of certain chemical changes, physical processes, and bacterial activities in the soil. His work revealed that there are several factors which may influence the microbial activities in the soil. As with bacteria, some of the conditions which may affect their growth are moisture, supply of oxygen, soil temperature, presence of organic matter, soil reaction, tillage, rainfall, and depth of sampling.

Review of Literature

Bear (1927) was of the opinion that the greater the number of bacteria in soil the more productive it is.

According to Waksman (1917) the fertile soils contain more fungi both in numbers and species than do those less fertile.

Lyon and Buckman (1927) state that *Actinomyces* are part of the army of workers by which the raw organic matter of various kinds are decomposed when incorporated in the soil. They state also that bacterial flora as well as other soil micro-organisms fluctuate markedly with respect to season, the number being largest in the summer months, in the latter part of June, in July, August, and in the earlier part of September.

Brown and Halverson (1919) claimed that the number of molds present in the soil fluctuated from one sampling to another, but it was apparently not affected by soil treatment, temperature, or moisture.

Brown and Benton (1930) observed that the variations in moisture content of the different soil layers in the soil samples studied

[2] UTZURRUM, JOSÉ B. The effects of certain fertilizers upon chemical properties and biological activities of Lipa clay loam soils. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture, 1933. Unpublished.)

seemed to have no definite relationship with the numbers of bacteria, *Actinomyces*, and molds.

Aquino (1932) was of the opinion that there was no correlation between the number of molds and bacteria in forest and non-forest soils.

Thornton and Gray, as cited by Corbet (1933), did not find any correlation between changes in bacterial numbers and soil moisture content, but rarely were soil temperature changes reflected in fluctuations of bacterial processes.

According to Aquino (1931), the reaction of the soils was not definitely correlated with the development of bacteria and molds in the soils.

Alicante (1926) states that when an organic fertilizer is applied to the soil several stages of biological reaction occur. The material is broken down into simpler forms by the action of groups of organisms, as molds, *Actinomyces*, and bacteria. Mineralization takes place in the case of organic fertilizers and other manurial materials in the soil as a result of the activities of bacteria and other related micro-organisms; also these organisms have the ability to break down the inorganic fertilizers and turn them into available form for the use of higher plants.

Tucay (1932) found that the transformation of insoluble organic substances into soluble forms for the purpose of being made available for use of plants may be attributed mainly to bacterial activities.

Greaves, Carter, and Geldthrope (1919) found that salts which may occur in soils, and those applied to them in various farm operations, influence the number, species, and activities of the micro-flora of the soil, and these in turn are reflected by the crop yields.

Noyes and Conner (1919) showed that the addition of calcium carbonate increased the bacterial content of the soil. The increase was largely in aerobic organisms.

The addition of lime, which made the soil basic, resulted in a decrease in the number of fungi and in an increase in the number of bacteria and *Actinomyces* (Waksman, 1921).

Pitz (1916) found that calcium sulfate, when added to the soil, has no marked effect on the total number of bacteria grown on agar plate.

Murray (1921) found that the addition of straw to the soil had a decided effect on the number of bacteria. The more straw added to the soil the larger was the number of bacteria. This finding seems

to be in accord with the results found by Waksman and Starkey (1924) which also show that the addition of straw and green manures to the soil increased the number of bacteria.

Rudolfs (1921) and Waksman (1921) were of the opinion that the biological flora expressed in number counted on agar plates from soil infusions was slightly stimulated by small sulphur application but larger amounts decreased the number.

The results of the studies of Brown (1916) show that there was no relation between the bacterial activities studied and the actual crop yield on the plots.

Objects of the Present Work

The objects of this study were: (*a*) To determine the effect of certain fertilizers and soil amendments and the number of micro-organisms, bacteria, molds, and *Actinomyces* on Nanhaya clay, a local alluvial soil. (*b*) To compare the seasonal fluctuation in the number of bacteria, molds, and *Actinomyces* as influenced by the application of fertilizers and soil amendments. (*c*) To determine whether there is any relation between the number of micro-organisms in the variously treated cultures and the yield of rice plants or not.

Time and Place of the Present Work

The work was begun on July 31, 1934, and concluded on January 2, 1936, a period of 17 months. The laboratory part was conducted in the Department of Soils, College of Agriculture.

MATERIALS AND METHODS

Materials. A local rice soil from the Experiment Station of the College of Agriculture, Los Baños, Laguna, was used in this study. Rice of the Ramai variety was used in the rice culture experiment. It was planted in 100 water-tight petroleum cans.

Method. The soil used was obtained from various places in the rice fields of the College Experiment Station. The soil was well mixed and the large clods broken up. Roots of various weeds were discarded and all the cans filled to within 5 centimeters of the top.

Rate and manner of application of fertilizers and soil amendments. The rate of application of the various fertilizers and soil amendments is shown in the tabulation. Rice straw, dried grass, and dried legume vines were cut into pieces before they were applied.

Most of the chemical fertilizers and soil amendments were dissolved in water before they were applied to the pot cultures. They

were applied only once during the course of this study. A sufficient amount of water was added to each of the variously treated cultures to maintain a depth of 3 centimeters during the growing period of the rice plants.

Different culture media. For the quantitative determination of the number of bacteria in the soil plate method with the "modified albumen", agar medium of Brown (1913) was used. The composition of this medium is:

Dextrose ($C_6H_{12}O_6$)	10.0 grams
Dipotassium phosphate (K_2HPO_4)	0.5 gram
Ferric sulfate ($Fe_2(SO_4)_3$)	trace
Magnesium sulfate ($MgSO_4.7H_2O$)	0.2 gram
Egg albumen	0.25 gram
Agar	15.00 grams
Distilled water	1000.00 cc.

The egg albumen was suspended in cold water and a few drops of one-tenth normal sodium hydroxide solution were added. This solution was mixed with the nutrient solution. The reaction of the medium was adjusted to pH 7.0.

For the determination of the number of molds in the soil the Waksman's (1922b) synthetic acid agar medium was used. It was prepared as follows:

Glucose ($C_6H_{12}O_6$)	10.0 grams
Peptone	5.0 grams
Monopotassium phosphate (K_2HPO_4)	1.0 gram
Magnesium sulfate ($MgSO_4$. $7H_2O$)	0.5 gram
Agar	25.0 grams
Distilled water	1000.00 cc.

The reaction of the medium was adjusted to pH 4.0.

For the determination of the number of *Actinomyces* the synthetic agar of Waksman (1919) was used. The formula of this medium is:

Agar	15.0 grams
Sodium nitrate ($NaNO_3$)	2.0 grams
Dipotassium phosphate (K_2HPO_4)	1.0 gram
Magnesium sulfate ($MgSO_4$. $7H_2O$)	0.5 gram
Potassium chloride (KCl)	0.5 gram
Ferrous sulfate ($FeSO_4$)	0.01 gram
Sucrose ($C_{12}H_{22}O_{11}$)	30.0 grams
Distilled water	1000.00 cc.

The reaction was adjusted to pH 7.0.

Preparation of different culture media. The different ingredients of the medium were weighed and placed in a casserole containing one liter of distilled water. The mixture was heated until the ingredients were all dissolved. Then 10 cc. portions of the medium were placed in the test tubes which were plugged with cotton and sterilized in the autoclave at fifteen pounds pressure for about twenty minutes.

ROW NUMBER	AMOUNT APPLIED PER CAN	RATES PER HECTARE	TREATMENT
	grams	*kgm.*	
1	—	—	Control
2	200.00	3412	Grass straw
3	200.00	3412	Grass straw
4	200.00	3412	Legume
5	20.00	341	$CaCO_3$
	200.00	3412	Grass straw
6	20.00	341	$CaCO_3$
	200.00	3412	Rice straw
7	3.00	51	$(NH_4)_2SO_4$
	200.00	3412	Rice straw
8	50.00	853	Rice straw ash
9	20.00	341	$CaCO_3$
10	40.00	632	$CaCO_3$
11	3.00	51	$(NH_4)_2SO_4$
12	6.00	101	$(NH_4)_2SO_4$
13	6.00	101	$(NH_4)_2SO_4$
	20.00	341	$CaCO_3$
14	2.50	42	$CaH_4(PO_4)_2$
15	5.00	85	$CaH_4(PO_4)_2$
16	4.00	68	KCl
17	8.00	136	KCl
18	4.00	68	KCl
	2.50	42	$CaH_4(PO_4)_2$
19	3.00	51	$(NH_4)_2SO_4$
	4.00	68	KCl
	2.50	42	$CaH_4(PO_4)_2$
20	3.00	51	$(NH_4)_2SO_4$
	2.50	42	$CaH_4(PO_4)_2$
21	0.75	12	Sulfur
22	1.50	25	Sulfur
23	1.50	25	Sulfur
	20.00	341	$CaCO_3$
24	5.00	85	NaCl
25	10.00	170	NaCl

Preparation of cultures. Pots: In this study 100 water-tight petroleum cans painted with coal tar were used. The cans were arranged in twenty-five rows, four cans in a row. They were spaced 10 cm. apart. These cans were buried in the ground exposing only about 10 centimeters. The four cans in each row were marked *a*, *b*, *c*, and *d*. Each can was filled with the soil to within about 5 centimeters of the top.

Method of planting. Rice of the Ramai variety was used. The seed was germinated in a can containing the same kind of soil used in this experiment. Four seedlings were transplanted in each can.

There were two plantings. The first planting was on January 30, 1934. Two weeks after transplanting, fertilizers and soil amendments were applied in accordance with the fertilization plan. The first sampling of soil was on July 31, 1934. Biweekly samplings followed until the first crop was harvested on December 26, 1934.

On January 31, 1935, the second planting of rice of Ramai variety was made, and the same cans and soil were used. Fertilizers and soil amendments were added to the soil two weeks after planting. Soil samples were collected in the usual manner and quantitative determinations of the number of bacteria, of *Actinomyces*, and of molds were made. The rice was harvested on January 2, 1936. The yield of palay and straw was recorded.

Care of cultures. A sufficient amount of water was added to each of the cultures to maintain the depth of three centimeters during the growing period of the rice plants. Weeds around the cultures and inside the cans were pulled up. The culture was fenced and provided with supporters during the booting stage.

Preparation of different dilutions. Ten-gram sample of soil was placed in a 100 cc. sterile water and then shaken for five minutes. With the use of 10 cc. sterile pipettes the following dilutions were made:

(*a*) 10 cc. of the infusion in 90 cc. sterile water: dilution 1:100.

(*b*) 10 cc. of (*a*) in 90 cc. sterile water: dilution 1:1000.

(*c*) 10 cc. of (*b*) in 90 cc. sterile water: dilution 1:10,000.

(*d*) 10 cc. of (*c*) in 90 cc. sterile water: dilution 1:100,000.

Dilution (*c*) was shaken thoroughly and one-cc. portions were transferred to the two Petri dishes for mold numbers.

For bacteria and *Actinomyces*, dilution (*d*) was used, following the same procedure.

Planting. The prepared sterilized media were melted. They were cooled to about 45°C. and immediately poured into their corresponding Petri dishes and mixed thoroughly by rotating each plate to secure a uniform mixture. All the agar plates were allowed to solidify on a smooth level surface.

The different agar plates were incubated in an inverted position at room temperature. Time for incubation for molds was 3 days; for bacteria, 7 days; and for *Actinomyces*, 14 days.

At the end of the incubation period, the colonies that developed on different plates were counted. The numbers of the organisms were calculated on the number in one gram of oven dry soil. The results are shown in figures 1, 2, and 3.

The moisture determination and soil reaction were also recorded and the results are presented in figures 1 and 2.

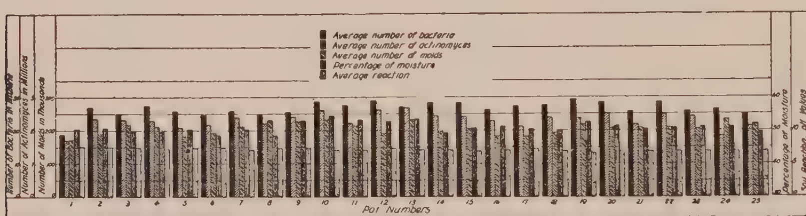

Fig. 1.—Average numbers of bacteria, actinomyces, molds, per cent of moisture and soil reaction in different cultures

RESULTS

Figure 1 shows the average numbers of bacteria, *Actinomyces*, molds, rate per cent of moisture, and pH values in the different cultures.

Figure 2 shows the average numbers of bacteria, of *Actinomyces*, of molds, and yields of palay and straw in the different cultures.

Figure 3 shows the average numbers of bacteria, *Actinomyces*, molds, rate per cent of moisture, and pH values at various dates of sampling.

DISCUSSION OF RESULTS

The effects of the application of certain fertilizers and soil amendments on Nanhaya clay

The data presented in figures 1, 2, and 3 show the enormous numbers of the different kinds of micro-organisms which occurred in the soils of the variously treated cultures. The application of fertilizers and soil amendments to clay soil exerted a stimulating

influence upon the numbers of micro-organisms. All the variously treated cultures showed variations in their content of micro-organisms. The number of microbes in each of the treated cultures was observed to be greater than those shown by the untreated or control. The largest number of bacteria, of *Actinomyces,* and of molds was shown by culture 13 which received a treatment of calcium carbonate and ammonium sulfate. There were found in this culture 27,080,000 bacteria, 2,685,000 *Actinomyces,* and 232,000 molds. Culture 19, which was treated with potassium chloride, ammonium sulfate, and superphosphate, also gave a high count of the micro-organisms, the average number of bacteria being 29,210,000, *Actinomyces,* 2,372,000, and molds, 217,000. The results showed that there was no apparent correlation between the number of micro-organisms in the variously treated cultures. An increase or a decrease in the number of bacteria did not show a corresponding increase or decrease in the number of *Actinomyces* and molds.

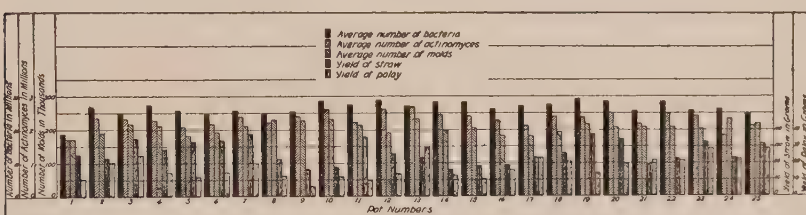

Fig. 2.—Average numbers of bacteria, actinomyces, molds, and yields of straw and palay of the variously treated cultures

Comparison of results of the fluctuation in the number of different kinds of organisms in variously treated soils

The average figures presented in figure 2 showed that the variously treated cultures differed in micro-organic population. In general, however, the number of micro-organisms in each of the treated cultures was greater than that shown by the untreated one or control. Culture 2, which received a treatment of rice straw, gave a greater number of micro-organisms than the one which received no treatment. In culture 3, the bacterial number increased and the *Actinomyces* and molds decreased in number. With 27,470,000 bacteria in culture, a decrease in the number of *Actinomyces* and molds was noted. In culture 5, all the micro-organisms decreased in number. While there was a decrease in bacterial number in culture 6, the *Actinomyces* and molds increased.

An increase in the number of micro-organisms in culture 7 was followed by a decrease in bacteria and in *Actinomyces* and an increase in mold count in culture 8. The number of both bacteria and *Actinomyces* increased but molds decreased in culture 9. Culture 10 showed a larger number of micro-organisms than culture 9, and a decrease in number of micro-organisms followed in culture 11. The counts of bacteria and *Actinomyces* in culture 12 continued to increase and the mold number showed a corresponding decrease. There seemed to be a regular fluctuation in the number of micro-organisms in all the rest of the cultures.

From the results obtained, it appears that there was a fluctuation of bacterial numbers in all of the treated cultures and that the bacterial count in each of the variously treated cultures was larger than that shown by the untreated ones. In general, there seemed to be a correlation between the number of bacteria and that of *Actinomyces* as they fluctuated during the different sampling periods. An increase as well as a decrease in the number of bacteria in the soil was observed to be accompanied by an increase and a decrease in the number of *Actinomyces*. The number of bacteria and of molds showed no definite relation. In the majority of cases, however, the *Actinomyces* and mold counts ran parallel.

The results of the determination of the moisture content of the soils used in the tests are also shown in figure 1. It is evident from the results obtained that there were no significant variations in the moisture content of the different cultures. It may be of interest to note that during the course of this study the moisture content of each of the different cultures was carefully maintained. While it is true that there were fluctuations in the amount of moisture in the different cultures during the different sampling periods, such fluctuations showed no correlation with the fluctuation of the number of micro-organic population of the soil (fig. 3).

Figure 1 showed that the hydrogen-ion concentrations (pH values) of the different cultures did not vary significantly in the variously treated cultures. It is evident from the results obtained that the hydrogen-ion concentrations of the soils of the different cultures showed no definite relation with the number of micro-organisms which varied in the different cultures and fluctuated at various dates of sampling.

Relationship between the number of micro-organisms and the yield of rice plants in treated soil cultures

Figure 2 showed the yields of palay and straw. The highest yield of palay was 29.25 grams which was obtained from culture 13 that was treated with ammonium sulfate and calcium carbonate. The lowest yield was 6.03 grams which was from culture 9 that received a treatment of calcium carbonate. The highest yield of straw

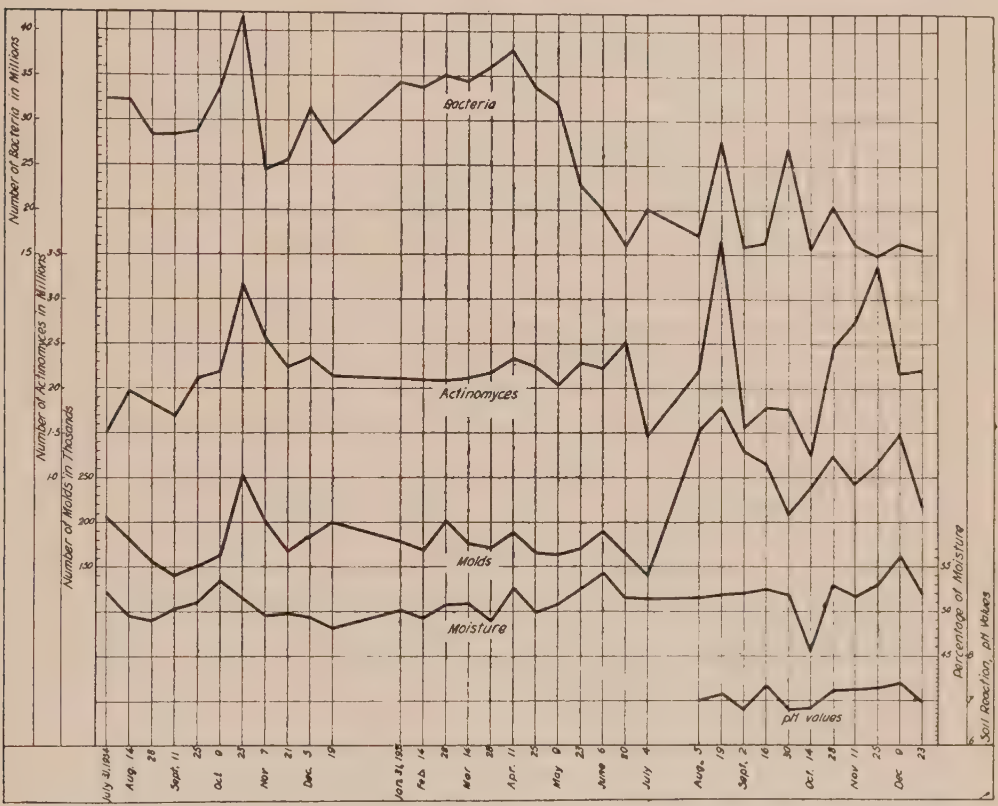

Fig. 3.—Average numbers of bacteria, actinomyces, molds, per cent of moisture, and soil reaction at different dates of sampling

was 150.0 grams which was obtained from culture 7 treated with rice straw and ammonium sulfate, and the lowest amount, 64.5 grams of straw, was from culture 14 treated with superphosphate.

Figure 2 showed the relationship between the number of bacteria, of *Actinomyces,* and of molds and the yields of grain and straw. A study of the results showed that a correlation seems to exist be-

tween the number of *Actinomyces* and the yield of palay. In general, an increase in the number of *Actinomyces* in the variously treated soils was followed by an increase in yield of grain. There was no relation between the bacterial numbers and mold counts nor did they bear any relation to the yield of grain. A correlation seems to exist between the number of bacteria and yield of straw, which did not correlate with the number of *Actinomyces* or molds.

SUMMARY AND CONCLUSIONS

1. A study of the effect of application of certain fertilizers and soil amendments on the number of micro-organisms in Nanhaya clay soil collected from rice fields of the College of Agriculture Experiment Station at Los Baños was made.

2. The fertilizers and soil amendments were applied two weeks after transplanting the rice seedlings in the different cultures. No further application was made during the progress of the work.

3. Fertilizers and soil amendments had a stimulating influence upon the numbers of micro-organisms in the Nanhaya clay soil.

4. The variously treated cultures differed in their content of bacteria, of *Actinomyces,* and of molds.

5. Soil culture 13 treated with calcium carbonate and ammonium sulfate gave the highest number of micro-organisms.

6. The number of bacteria, of *Actinomyces,* and of molds fluctuated in the different periods of sampling.

7. In general, a correlation existed between the number of bacteria and that of *Actinomyces* as they fluctuated during the different sampling periods. The number of bacteria and of molds, however, showed no correlation. In the majority of cases, the counts of *Actinomyces* and of molds ran parallel.

8. There were no significant variations in the moisture content of the different cultures. During the different sampling periods there was no correlation between the percentage of moisture, and the number of micro-organic population of the soil.

9. The hydrogen-ion concentrations (pH values) of the different cultures did not vary significantly in the various treated cultures. No correlation existed between the number of micro-organisms and the reactions of the soils in the different cultures.

10. The highest yield of palay was obtained from culture 13 which received a treatment of calcium carbonate and ammonium sulfate; and culture 9, treated with calcium carbonate, showed the

lowest yield. The highest yield of straw was obtained from culture 7, treated with ammonium sulfate and rice straw; and the lowest, from culture 14 treated with superphosphate.

11. A correlation was found to exist between the number of *Actinomyces* and the yield of palay.

12. An increase in bacterial count in all the soils of various cultures was observed to be, in general, accompanied by an increase in yield of straw.

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A STUDY OF THE STORAGE TEMPERATURE REQUIREMENT OF THE FRUIT OF ATIS, ANONA SQUAMOSA LINN.[1]

PHANOM SMITANANDA

Among the less important Philippine fruits generally considered, the atis, *Anona squamosa* Linn. also known as sugar-apple and sweet-sop, may be considered a promising fruit of commerce.

Because of its delicate flavor a good atis fruit is eaten with enjoyment by both Filipinos and foreigners. The atis possesses a "cosmopolitan" taste.

The good demand for the atis is only partly filled by the supply at the present time, as there is only one fruit per capita in the country. According to the report of the Bureau of Statistics, Department of Agriculture and Commerce, in 1932, there were, out of 1,310,250 atis trees, 680,150 bearing. In the same year the area under atis cultivation was 2,620 hectares. The number of fruits harvested in that year was 14,759,200 the market value of which was ₱221,390. The price of these fruits ranged from ₱1.10 to ₱3.30 per hundred.

The atis tree grows in almost all localities. It thrives well under tropical conditions and bears within three to five years after planting. The fact that atis trees are found in most of the Filipino yards indicates the ease in culture of the plant.

The fruit has a variety of uses. In the home it is generally served as fresh fruit. It is also popular for icecream-making, or the frozen fruit may be served as such. In Siamese homes, atis with coconut milk is one of the most popular preparations served with ice.

Occasionally, the atis is mixed with juice of other fruits for the preparation of jellies and preserves.

One objection to the atis fruit is its perishable nature. Under ordinary conditions, it ripens in from two to three days after picking, depending upon the stage of maturity of the fruit at picking time.

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[1] Thesis presented for graduation, 1934, with the degree of Bachelor of Science in Agriculture. No. 973. Experiment Station contribution No. 1190. Prepared in the Department of Agronomy under the direction of Dr. L. G. Gonzalez.

When ripe, it remains in marketable condition for only two days. Any information on methods of prolonging the life of the fruit should be of importance in encouraging atis culture.

Of the known methods of prolonging the life of fresh perishable fruits and vegetables, cold storage is known to give the most satisfactory results; hence, the use of this method in approaching the problem.

Review of literature

In the search for literature on the storage of atis fruit, the writer did not succeed in locating any. Instead, notes on other phases of study on the atis were found. They are rather fragmentary and are not easily obtainable, and it seems that they might be more useful if they are put together. Hence, an attempt was made to include as many as possible of the short notes in this review.

According to De Leon (1916), the atis is the most widely grown of the *Anonas* in the Philippine Islands. He claims that it ranks with the cherimoya, *Anona cherimolia* Mill., and that it has a flavor that makes it popular.

De Candolle (1919) presents evidence that the atis is a native of Tropical America. Wester (1913) mentions that the plant grows well from sea level to an elevation of 850 meters, even if the locality has a long dry season.

Popenoe (1924) reported that the atis plant grows well in a hot and relatively dry climate as in interior plains of many tropical countries. He also reported that in Central America it is rarely seen at an elevation greater than 2,500 feet. He stated that mature plants are not seriously injured by a temperature of 28° or 29°F., but that young ones may be killed by a temperature of 30°F.

The atis is quite rich in protein, carbohydrates, and sugar contents as compared with other fruits. Results of different chemical analyses reported by Pratt and Del Rosario (1913), Popenoe (1924), Adriano (1925), and Adriano and Tavanlar (1925) show that the fruit contains the following constituents: total solids 24.82 per cent, moisture 76.18 to 76.21 per cent, edible portion 52 to 58.23 per cent, protein 1.12 to 1.67 per cent, carbohydrates 19.16 per cent, fat 0.54 to 1.10 per cent, sugar 18.15 per cent or reducing sugar 15.77 per cent, and sucrose 0.22 per cent, sugar ratio 107, calorific value per 100 grams of fruit 95.63, fiber 1.22 to 1.16 per cent, 0.12 per cent H_2SO_4, 0.12 per cent malic acid, ash 0.67 to 0.97 per cent, 0.08 per cent as K_2CO_3 in ash, and 0.023 per cent calcium oxide, 3 per cent of which is in ash and 0.1 per cent in dry matter.

Villanueva (1925) reported that tannin is absent in the bark or stem, leaf, root, and fruit.

Hermano and Sepulveda (1934) reported that the atis fruit is an excellent source of vitamin C.

Adriano, Valenzuela, and Miranda (1933) found that frozen atis pulp, with or without syrup, kept well in storage at 18°F. (-6.6°C) for two months.

Bailey (1924) reported that atis fruits may be used in the preparation of jellies and preserves.

Reinking (1919) reported that the atis plant is subject to the attacks of Pink disease caused by *Corticium salmonicolor* B. et Br.. He also found *Polyporus regulosus* Lév. on the dead wood.

Uichanco (1930) reported as atis pests in the Philippines two species of coccids, *Ferrisia virgata* Ckll. and *Pseudococcus lilacinus* Ckll., and the following Lepidoptera: *Papilio agamemnon* Linn., *Autoba quisescens* Warren, *Dichocrosis punctiferalis* Guen., *Heterographis bengalella* Rag., *Sylepta sabinusalis* Walk., and *Attacus atlas* Linn.

Object, time, and place of the work

The objects of the work were to find the optimum storage temperature of atis fruit and to study the effects of low temperature on certain physiological activities of this fruit. The work was conducted in the Department of Agronomy of this College from June, 1933, to September, 1934.

MATERIALS AND METHODS

Freezing point

Workers on the subject of cold storage of fruits, including Overholser (1922), Carrick (1924), Chandler (1925), and Carrick (1930), were of the opinion that since it is desired to prolong as much as possible the ripening and to delay the breaking-down process of fruit in storage, this end is assumed to be accomplished by maintaining the storage temperature as low as possible without freezing the fruit. Consequently, it seems necessary to know the initial freezing point of the cell sap in contact with the protoplasm, as well as the effect of subsequent degrees of freezing upon the tissue.

In the present work the freezing point of the sap was determined with the Beckman thermometer. Only ripe fruits were used in these determinations. One fruit was peeled at a time, and the pulp was placed in a dry, clean beaker. By using two pieces of chromium-plat-

ed wires, which were manipulated so as to function like a fork, the seeds were removed carefully and quickly so as to minimize the drying of the pulp.

The pulp was then crushed in a porcelain mortar and two 10-cc. aliquots were placed in 25-cc. clean, dry test tubes. For the cryoscopic determinations, these test tubes were placed in a larger tube, one at a time, in order to furnish a double wall. The salt-ice mixture used for freezing was contained in an 18 × 7 cm. glass jar that was insulated with a 4-cm. layer of sawdust. After every duplicate determination, the freezing point of distilled water was determined so as to correct the observed freezing point of the pulp.

The following formula, suggested by Harris and Gortner (1924) for correction of under-cooled solutions, was used in finding the corrected freezing points:

$$\triangle = \triangle' - (0.0125 U \triangle')$$

In this equation, $\triangle'$ is the observed maximum freezing point, 0.0125 the heat of liquefaction of ice, and U the amount of undercooling.

The following formula for the calculation of the osmotic pressure of the cell sap was given by Lewis (1908) and cited by Morgan (1914):

$$P = 12.06\triangle - 0.021\triangle$$

where P is the osmotic pressure in atmospheres, and $\triangle$ is the depression of the freezing point in degrees centigrade.

Cold-storage chambers

The refrigerating chambers used in this experiment were similar to those used by San Pedro (1936): a five-gallon kerosene can with top removed was soldered to the bottom of another can made of galvanized iron having the dimensions 55 × 55 × 48 centimeters. The cover of the inner can was made of galvanized iron. It was very well fitted to the can. The cover of the outer can was made of wood having the dimensions of 63 × 63 × 2 centimeters. The surrounding space between the two cans measured 16 centimeters. The outer can served as water-bath, and the inner can as storage chamber. To the bottom of the outer can, a small tube made of galvanized iron was soldered for the purpose of draining off the water during the

adjustment of temperatures. Two of the outer cans were placed in a wooden box, having the allowance on all sides of about 10 centimeters, in which rice hulls were placed for purposes of insulation. The covering of the box was made of wood having the same thickness as the cover of the water-bath; it was well fitted to the box.

Fruits used

The fruits used in the storage work and in the study of the freezing point were obtained in the towns of Los Baños and Calamba, Laguna. They were of commercial pick; that is, some of them were hard but mature, while others were about ripe. They were classified and cleansed with a soft brush dipped in water to remove scale insects, and then placed in the laboratory to dry. The fruits were placed in the refrigerating chamber within twenty-four hours after picking.

Storage temperatures

The temperature used in this storage experiment were 0°, 5°, 10°, 13°, 15°, 18°, and 27.5°C. The work was divided into two parts; in the first, 0°, 5°, 10°, 15°, and 27.5°C. were used; and to supplement the results of the first part, the second part was conducted, using the temperatures of 13°, 15°, 18°, and 27.5°C. Maximum variations of the temperatures were as follows: 4.5° to 6.0° for 5°; 9.5° to 11.0° for 10°; 12.5° to 14.0° for 13°; 14.5° to 16.0° for 15°; 17.5° to 19.0° for 18°; and 27.0° to 27.5° for 27.5°C. The 0°C. was maintained by filling the bath with crushed ice and draining off water twice a day. Temperatures were adjusted at least four times a day; at 6 a. m., at noon, at 5 p. m., and at 11 p. m.

Each experiment was repeated at least twice, in case the results of the experiments were similar; but when there was doubt as to the effects of the treatment, more trials were made. At least twenty fruits were used in each trial for each temperature employed.

The fruits in the storage chamber were laid on a rack, making it possible to lift the fruits without touching them. This facilitated the work of examining the fruits. *Color Standard and Color Nomenclature* by Ridgway (1912) was used in checking color changes in the fruit.

Respiration

The method followed and apparatus used in this experiment were similar to those employed by Gonzalez (1931) in his study of

the respiration of the chico, *Achras zapota* Linn., which this author described as follows:

> The output of carbon dioxide of the fruit was determined by the titrametric method. The fruits were placed in a desiccator the side of which was carefully sealed with thick vaseline and further coated with two layers of shellac and tested for air leak by submersion in water. Two exits on top of the desiccator properly connected with pieces of glass and rubber tubings offer a good means of testing the apparatus for possible leak. One of the exits was closed with a pinch-cock while a gentle blow on the other end of the rubber tubing caused a slight pressure which proved to be very efficient in determining any opening on the desiccator however minute the size of the hole. The desiccator was then attached to a series of carbon dioxide-washing solutions contained in a relay of Erlenmeyer flasks, connected by glass and rubber tubings. This carbon dioxide-cleaning mixture was made up of a bottle of dry soda-lime, two flasks of saturated potassium solution, two flasks of strong barium hydroxide solution, and a bottle of dry calcium chloride crystals. To the other end of the desiccator was connected a suction flask fitted with a Reiset tube about half a meter tall containing a layer of fine glass beads suspended by a perforated rubber stopper. This tube in turn was connected to a trap bottle, then to the aspirator. The desiccator was placed in a properly insulated water bath.
>
> Two lots were run each time. Air was drawn at least twelve hours before any determination was made of the carbon-dioxide output of the fruit. Tenth-normal barium hydroxide solution was used for absorbing the carbon dioxide. Titration with tenth-normal oxalic acid showed the amount of alkali used by the fruit. The amount of carbon dioxide was calculated from this and the values were expressed in milligrams carbon dioxide per kilogram of fruit per hour duration of the experiment. The barium hydroxide used was always in excess of the estimated CO_2 from the fruit.

Temperatures used in this part of the experiment were 0°, 5°, 10°, 15°, and 27.5°C. The method of controlling the temperatures was similar to that in the storage work, but in addition to this, the adjustments of temperatures were made more often so that the fluctuation did not go beyond 0.5° of the required temperatures.

EXPERIMENTS AND RESULTS

Freezing point study of ripe atis

In the freezing point study, twenty determinations were made using ripe fruits obtained from Calamba and from Los Baños. Duplicate determinations were made using one fruit at a time. The results of the experiment may be seen in table 1.

Cold-storage study of unripe atis

A total of 360 unripe fruits was used in this part of the experiment. The study was conducted in two periods.

In the first period the temperatures used were 0°, 5°, 10°, 15°, and 27.5°C. In each temperature was placed a lot of 20 fruits, thus using 100 fruits in each set of experiment. The experiment was repeated using similar materials and the fruits were similarly treated.

To supplement the results previously obtained in the first period, the experiment was again conducted, using fruits of the stage of maturity similar to that used in the first period. The fruits were made up into 4 lots, each composed of 10 fruits and placed at 13°, 15°, 18°, and 27.5°C. The experiment was repeated four times using a total number of 160 fruits. Table 2 shows the results of the experiment.

Cold-storage study of ripe atis

The experiment on cold storage was repeated twice, using ripe fruits and the same temperatures as above. A total of 205 fruits was used in this part of the experiment. The details of the experiment and results obtained are presented in table 3.

Respiration study of unripe and ripe atis

In the respiration experiment, fruits from the same lots as used in the foregoing experiments were selected. The number of fruits used was rather limited because not more than one-half of a kilogram could be contained in each desiccator. The details of the experiment together with the results obtained are shown in tables 4 to 13.

DISCUSSION OF RESULTS

Freezing point of ripe atis

Data presented in table 1 show that there is no significant difference between the freezing points in the duplicate determinations. The greatest difference obtained, 0.082°C. (0.966 atmospheres), was exhibited by samples 1a and 1b; while the smallest, 0.003°C. (0.029 atmospheres), was between samples 6a and 6b.

Based on a comparison of the differences existing between two fruits (average of duplicate determinations), the highest freezing point was obtained in sample 5, -3.699°C. (43.843 atmospheres), and the lowest in sample 1, -3.42°C. (40.536 atmospheres).

The average freezing point of all determinations is -3.566±0.002°C. (42.260 atmospheres).

When the determinations on fruits obtained from Calamba are compared with those obtained from Los Baños, the range in the former set per determination is from -3.380°C. to -3.703°C., while

in the latter, it is from -3.548°C. to -3.687°C. The averages of the two groups of fruits are -3.511 ± 0.003° and 3.621 ± 0.002°C., respectively. The difference between the two means is significant (0.110 ± 0.0036°C.) but too small to be of pratical value.

It is interesting to compare the freezing points of ripe atis with those of other fruits. For instance, among tropical fruits the following are known: the chico -3.35°C. (Campo, 1935), the lanzon -1.378°C. (San Pedro, 1936), and Jamaica banana -3.33°C. (26°F.) (Wright and Taylor, 1923). Among the temperate fruits are the following: Baldwin apple -2.6°C. (27.32°F.), Wagener apple -1.54°C. (29.23°F.) (Carrick, 1928), Emperor grape -3.56°C. (25.6°F.), Flame Tokay grape -3.39°C. (25.88°F.), Malaga grape -3.64°C. (27.45°F.) (Carrick, 1930), strawberries -1.11°C. (29.93°F.), peaches -1.89°C. (29.41°F.), plums -2.44°C. (28.53°F.) (Wright and Taylor, 1923), and Triumph pomelo -2.15°C., Valencia oranges (Red Ball and Green Leaf Brands) -2.55°C., Washington Navel orange -2.58°C., Eureka lemon (Silver Moon Brand) -2.53°C., and -1.97°C. (Yorba Brand) (Gonzalez, 1927). It seems that with the exception of grapes in the temperate fruits and lanzones in the tropical fruits, the temperate zone fruits have higher freezing points than the tropical.

Cold storage of ripe atis

From the data given above, it would appear that the lowest temperature that may be used in the storage of ripe atis without freezing the pulp of the fruit is -3.703°C. As most storage plants have rather wide fluctuations in temperature, it would be necessary to raise the minimum temperature as an insurance against occasional drop. Thus a temperature of 0°C. or perhaps up to -1°C., if the storage is thermostatically controlled, would be ample. This assumption, however, takes for granted that the fruit is not adversely influenced by low temperature.

Actual findings in this experiment, however, proved that the ripe fruit behaved best at 5°C. At this temperature it lasted for seven days, although not more than five could be considered of market importance. After five days, the appearance, texture, and flavor of the fruit were similar to those of a specimen ripened at room temperature. The flavor of the fruit was still normal up to the seventh day, but the appearance of tawny-colored spots on the surface, together with the rather soft texture of the fruit, made it lose its market value.

At 0°C. the maximum storage period of the atis was only three days. Thereafter, the flavor turned flat, the texture became rather sandy, and the color, dull violet black; so the fruit no longer had any market value.

At temperatures higher than 5°C., the market quality of the fruit was considerably shortened, being a maximum of five days at 10°, three days at 15°, and at 27.5°C. the ripe fruit kept only for a day.

Cold storage of unripe atis

At ordinary room temperature, 27.5°C., unripe atis ripened within two days and the fruit might be safely kept in good condition to the third day, after which the fruit began to decrease in its market value.

The fruit did not ripen at 13°C. if placed at that temperature continuously. It turned black soon after the twelfth day, remaining hard without reaching an edible stage. If, however, the fruits were removed to room temperature at about the twelfth day, ripening took place within four days and the fruits acquired a taste similar to specimens picked rather immature, corresponding to what is commonly sold in the market, possessing full aroma but lacking in sweetness.

At temperatures lower than 13°C. the fruits did not ripen at all, even when they were removed to 27.5°C. after eight days.

At 15°C., the unripe fruit behaved best. The ripening period was considerably retarded without causing any abnormality. The fruit was ripe at the end of the eighth day. The flavor was normal and the general eating quality similar to a specimen ripened at room temperature. At temperatures higher than 15°C., the number of storage days was considerably less. Thus, it seems that for the unripe fruit, storage at 15°C. is the best.

Respiration study of atis

The rate of respiration of the atis increases from the unripe to the ripe stage. In table 13, it may be seen that the average rate of respiration of mature unripe atis was 137.34; of half-ripe, 224.10; of ripe, 283.55; and of over-ripe, 318.87, all in milligrams CO_2 per kilogram of fruit per hour. These figures are based on the respiration of the different stages of the fruit under the same temperature. The increase in respiratory rate is perhaps due to an increase in available sugar, which can readily be detected through marked changes

in the flavor of the fruit during the different stages mentioned. This finding is in agreement with the opinion of Chandler (1925) that fruit respires most during the ripening process.

The influence of temperature on respiration is equally important. With unripe atis (tables 9 to 13), the rate of respiration at 0°C. was 17.40 milligrams per kilogram hour; at 5°C., 28.42; at 10°C., 40.92; at 15°C., 57.06; and at 27.5°C., 137.34. If the rate of respiration at O°C. is taken as 1, relative values at other temperatures will be 1.5 at 5°; 2.5 at 10°; 3 at 15°; and 9 at 27.5°C. For the ripe fruit (tables 4 to 8), values will be 1 at 0°; 1.5 at 5°; 3 at 10°; 9 at 15°; and 15 at 27.5°C. Similar increases in rate of respiration at higher temperatures have been reported by early workers on the subject, including Morse (1908), Gore (1911), Overholser (1922), Carrick (1924), Carrick (1926), Gonzalez (1927), Carrick (1927), and Gonzalez (1931).

SUMMARY AND CONCLUSIONS

1. The freezing point of ripe atis varied from -3.703°C. to -3.380°C., with an average of -3.566 ± 0.002°C.

2. Ripe atis fruits from Calamba had an average freezing point of -3.511 ± 0.003°C., from Los Baños, -3.621 ± 0.002°C. The difference (0.110 ± 0.0036°C.) is significant but too small to be of practical value.

3. For storage of ripe fruit the best result was obtained by using the temperature of 5°C. The life of the fruit was lengthened to five days, as against one day at ordinary room temperature.

4. For unripe atis, 15°C. proved to be the best temperature for storage. The fruit kept at least four times as long as that at ordinary room condition, or eight days in storage as against two days at 27.5°C.

5. Unripe atis may be stored at 13°C. for twelve days, after which it may be transferred to 27.5°C., when it will ripen within four days.

6. The rate of respiration of atis increases steadily from 21.63 milligrams per kilogram hour at 0°C. to 137.34 at 27.5°C., using unripe fruit.

7. As the atis ripens, there is a gradual increase in the rate of respiration, and this is independent of the storage temperature used. In the green stage, the rate is 137.34 milligrams per kilogram hour; in the ripe stage, 283.55 milligrams.

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TABLE 1

Freezing point of ripe atis fruit

SAMPLE NUMBER	FREEZING POINT	OSMOTIC PRESSURE
	−°C.	*atmospheres*
1 a	3.462	41.019
1 b	3.380	40.053
2 a	3.592	42.563
2 b	3.570	42.348
3 a	3.392	40.195
3 b	3.471	41.130
4 a	3.422	40.550
4 b	3.424	40.579
5 a	3.703	43.882
5 b	3.696	43.801
6 a	3.620	42.894
6 b	3.617	42.865
7 a	3.628	42.988
7 b	3.556	42.133
8 a	3.649	43.237
8 b	3.628	42.988
9 a	3.548	42.042
9 b	3.591	42.558
10 a	3.686	43.677
10 b	3.687	43.695
Average . . .	3.566 ± 0.002	42.260

TABLE 2

Influence of temperature on flavor and keeping quality of ripe atis

STORAGE TEMPERATURE	PERIOD IN STORAGE	TOTAL NUMBER OF FRUITS USED	CONDITION OF FRUITS WHEN INSPECTED				
			color	flavor	texture	quality	general appearance
°C.	days						
0	2	41	dull green yellow	normal	normal	good	normal
	4		Hay's russet	normal	a little sandy	poor	edible; appearance not good for market
	6		dull violet black	flat	sandy	poor	hard; segments cracked
5	4	41	dull green yellow	normal	normal	excellent	normal
	6		tawny spots	normal	soft	fair	good for eating
	8		tawny	slightly acidic	very soft	poor	not good for market
10	2	41	dull green yellow	normal	normal	very good	normal
	4		tawny spots	normal	soft	fair	good for eating
	6		tawny	slightly acidic	very soft	poor	not good for eating
15	2	41	dull green yellow	normal	normal	excellent	normal
	4		tawny	very slightly acidic	soft	poor	not good for eating
	6		Hay's russet	fermented	very soft	very poor	inedible
27.5	1	41	dull green yellow	normal	soft	very good	segments collapsed
	2		dark vivid brown	very slightly acidic	very soft	poor	segments collapsed; not very good for eating
	3		tawny	fermented	watery	very poor	inedible

TABLE 3

Influence of temperature on the ripening and keeping quality of mature green atis

STORAGE TEMPERATURE	PERIOD IN STORAGE	TOTAL NUMBER OF FRUITS USED	CONDITION OF FRUITS WHEN INSPECTED				
			color	flavor	texture	quality	general appearance
°C.	days						
0	2	40	Lumiere green		hard		normal
	3		Lumiere green		hard		normal [a]
	4		orange cinammon dots		hard		still good for market
	6		tawny		hard		not good for market
5	8	40	Lumiere green		hard		normal [a]
	10		burnt umber spots		hard		not good enough for market
	12		burnt umber spots		hard		not ripened, not good for market
10	8	40	Lumiere green		hard		normal [a]
	10		dull violet spots		hard		not ripened, not good for market
13	12	40	Lumiere green		hard		normal [b]
	14		burnt umber spots		hard		not ripened, not quite good for market
	16		burnt umber spots		hard		not good for market
15	8	80	Lumiere green	not very sweet	ripened	fair	normal
	10		dull green yellow	very sweet	soft	good	good for market
	12		tawny dots	sweet	soft and watery	poor	not good for market
18	4	40	dull yellow green	not very sweet	ripened	good	normal
	6		dull yellow green	very sweet	soft	good	some segments collapsed
	8		tawny dots	sweet	watery	poor	not good for market
27.5	1	80	Lumiere green	flat	hard, not ripened		normal green fruit
	2		dull yellow green	normal	ripened, soft	excellent	beginning to lose form
	3		dull yellow green	normal	soft	good	too soft
	4		dark vivid brown	slightly acidic	watery	poor	segments cracked, not good for market

[a] Fruits did not ripen though they were transferred to 27.5°C.
[b] Ripened within four days after being transferred to 27.5°C.

TABLE 4

Respiration of ripe atis at 0°C.

DATE		TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
				sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1934			*hours*					
September	2	1	2	21.57		21.79		
		2	2	21.43		21.93		
		3	2	21.57	21.52	21.51	21.74	21.63
	3	4	2	21.71		21.93		
		5	2	21.43		21.23		
		6	3	20.63	21.26	20.82	21.33	21.29
	4	7	2	21.01		20.95		
		8	2	20.88		20.90		
		9	2	20.74	20.88	21.09	20.98	20.93
	5	10	2	20.46		20.68		
		11	2	20.32		20.26		
		12	4	20.32	20.37	20.54	20.49	20.43
	6	13	2	19.63		20.26		
		14	2	19.77		19.57		
		15	2	19.63	19.68	19.84	19.89	19.78
	7	16	2	19.49		19.57		
		17	2	20.05		19.84		
		18	2	19.63	19.72	19.98	19.80	19.76

TABLE 5

Respiration of ripe atis at 5°C.

DATE		TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
				sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1934			*hours*					
September	2	1	2	29.73		29.42		
		2	2	29.22		29.04		
		3	2	27.81	28.92	27.48	28.65	28.78
	3	4	2	27.52		27.03		
		5	2.5	28.17		28.43		
		6	4	28.63	28.11	28.82	28.09	28.10
	4	7	2	26.93		27.03		
		8	2	27.07		27.48		
		9	2	27.22	27.07	27.33	27.28	27.17
	5	10	2	27.37		27.33		
		11	2	27.52		27.48		
		12	2	27.07	27.32	27.18	27.33	27.32
	6	13	2	26.33		26.73		
		14	2	26.48		26.28		
		15	2	25.89	26.23	26.13	26.38	26.30
	7	16	2	25.89		25.83		
		17	2	25.30		25.24		
		18	2	25.60	25.60	25.39	25.49	25.54
	8	19	2	25.00		24.79		
		20	2	24.86	24.93	24.94	24.86	24.89

TABLE 6

Respiration of ripe atis at 10°C.

DATE		TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
				sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1933			*hours*					
October	25	1	2	58.26		55.43		
		2	2	60.59		56.69		
		3	2	55.93	58.26	57.95	56.69	57.48
	26	4	3	58.96		56.69		
		5	2	60.59		56.69		
		6	2	59.43	59.66	59.21	57.53	58.60
	27	7	2	59.90		57.91		
		8	3	55.93		55.43		
		9	2	58.26	58.03	56.19	56.52	57.28
	28	10	2	53.60		56.69		
		11	3	53.60		52.91		
		12	2	50.11	52.44	54.17	54.59	54.14

TABLE 7

Respiration of ripe atis at 15°C.

DATE		TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
				sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1933			*hours*					
October	25	1	1	186.75		188.97		
		2	1	180.47		190.69		
		3	1	182.04		188.97		
		4	2	185.18	183.61	188.12	189.19	186.40
	26	5	1	169.49		178.66		
		6	1	160.07		176.95		
		7	2	166.35	165.30	178.66	179.09	171.74
	27	8	1	158.50		158.91		
		9	1	153.79		159.76		
		10	1	155.36		158.05		
		11	1	152.22		154.61		
		12	1	155.36	155.05	158.05	157.88	156.46

TABLE 8

Respiration of ripe atis at 27.5°C.

DATE		TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
				sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1934			*hours*					
July	15	1	1	294.23		297.27		
		2	1	290.31		297.27		
		3	2	302.74	295.76	305.17	299.90	297.83
	16	4	2	288.18		285.50		
		5	1.5	261.99		267.90		
		6	1	263.33	271.17	266.02	273.14	272.15
	17	7	1	246.54		251.91		
		8	1	245.86	246.20	244.52	248.22	247.21

TABLE 9

Respiration of green atis at 0°C.

DATE	TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
			sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1933		*hours*					
November 12	1	3	17.59		15.99		
	2	2	18.51		16.63		
	3	3	18.51	18.30	16.88	16.50	17.40
13	4	3	17.04		14.71		
	5	3	18.88	17.96	14.45	14.58	16.27
14	6	3	16.10		15.35		
	7	3	18.20		15.60		
	8	2	17.22	17.17	17.65	16.20	16.68
15	9	3	15.73		16.37		
	10	3	16.66	16.19	16.24	16.30	16.24
16	11	2	14.81		17.27		
	12	2	14.44		16.63		
	13	3	14.84	14.70	15.99	16.63	15.66
17	14	3	14.44	14.44	16.37	16.37	15.40

TABLE 10

Respiration of green atis at 5°C.

DATE	TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
			sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1933		*hours*					
November 12	1	2	28.32		27.72		
	2	2	27.86		27.72		
	3	2	29.93	28.70	28.98	28.14	28.42
13	4	2	27.63		29.48		
	5	2	29.24		28.98		
	6	2	29.93	28.93	28.22	28.89	28.91
14	7	2	29.93		26.46		
	8	2	27.63	28.78	28.98	27.72	28.25
15	9	2	26.94		27.72		
	10	2	26.48	26.71	28.98	28.35	27.53
16	11	2	27.63		28.98		
	12	2	27.63	27.63	29.98	28.98	28.30

TABLE 11

Respiration of green atis at 10°C.

DATE	TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
			sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1933		*hours*					
November 7	1	2	38.50		41.42		
	2	2	42.02		41.42		
	3	2	40.73	40.42	41.42	41.42	40.92
8	4	2	42.58		40.56		
	5	2	40.73		38.83		
	6	2	43.50	42.27	37.97	39.12	40.69
9	7	2	36.09		35.38		
	8	2	32.39		32.79		
	9	2	35.17	34.55	33.65	33.94	34.24
10	10	2	28.69		28.48		
	11	2	29.62		28.82		
	12	2	27.77	28.69	27.61	28.30	28.49

TABLE 12

Respiration of green atis at 15°C.

DATE	TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR				
			sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2
1933		*hours*					
November 7	1	2	57.58		57.95		
	2	2	56.43		57.20		
	3	2	55.28	56.43	57.95	57.70	57.06
8	4	2	56.89		54.68		
	5	2	56.43		56.69		
	6	2	55.74	56.35	55.94	55.77	56.06
9	7	2	55.74		56.69		
	8	2	57.58		57.20		
	9	2	56.89	56.74	57.95	57.28	57.01
10	10	2	57.58		57.20		
	11	2	56.98		57.95		
	12	2	58.04	57.53	57.20	57.45	57.49

TABLE 13

Respiration of ripening atis at 27.5°C.

DATE	TITRATION NUMBER	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM PER HOUR					STAGE OF RIPENESS OF THE FRUIT
			sample 1	daily average	sample 2	daily average	daily average of samples 1 and 2	
1934		*hours*						
August 18	1	1.5	131.78		132.83			
	2	2.0	136.79		137.67			
	3	1.5	142.05	136.87	142.95	137.82	137.34	unripe
19	4	2.0	216.18		219.05			
	5	2.0	225.42		229.16			
	6	2.0	226.11	222.57	228.72	225.64	224.10	half-ripe
20	7	1.5	276.16		280.62			
	8	1.5	278.75		282.38			
	9	2.0	287.38		289.42			
	10	1.5	285.65	281.98	288.10	285.13	283.55	ripe
21	11	1.5	311.28		316.69			
	12	1.5	316.12		317.57			
	13	1.5	324.06	317.15	327.51	320.59	318.87	over-ripe

EFFECTS ON DRY MATTER AND ASH CONTENT OF RICE PLANTS BY VARYING THE AMOUNTS OF AMMONIUM SULFATE [1]

VIRGILIO T. ALMEDA

WITH TWELVE TEXT FIGURES

That ammonium sulfate fertilizer exerts a considerable influence on the growth and yield of the rice plant has been known for sometime. Results of culture studies in the Department of Agricultural Botany at Los Baños showed, among other things, that as the amount of ammonium sulfate fertilizer in pot cultures was increased there was a corresponding increase in the yield of top of rice. Even the color of the leaves was affected; it became more intense green as the amount of fertilizer was increased.

Thus, in one way, these results appear very desirable and would have been most welcome had it not been for the fact that, contrary to what might be expected, the effects on yield of grain were adverse. Instead of a high yield of grain, which should be commensurate with the size of the tops producing it, the yield was relatively low. Moreover, it was observed that as a consequence of a relatively heavy application of ammonium sulfate fertilizer, the fruiting or maturity of grains was delayed by several days, and the grains thus produced did not ripen simultaneously.

In an effort to find a probable explanation for such apparently harmful effects on the yield of rice, a series of studies using pot cultures was started. Libatique (1931) began the series and looked into the comparative development of the roots and leaves of the plant as influenced by varying amounts of ammonium sulfate fertilizer in the soil. Soriano (1934) followed with another comparative-culture study on the effects upon the chlorophyll content of the leaves of rice by varying the amount of ammonium sulfate in the soil. In the present study, an attempt was made to seek the desired explanation among the data obtained on dry matter and ash contents, especially of the aerial part of the rice plant.

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[1] Thesis presented for graduation from the College of Agriculture, 1937, with the degree of Bachelor of Science in Agriculture, No. 1068. Experiment Station contribution No. 1191. Prepared in the Department of Agricultural Botany under the direction of Professor Rafael B. Espino.

Review of literature

Soriano (1934) grew rice plants in pots and found that as the amount of ammonium sulfate fertilizer was increased there was a relative increase in the chlorophyll content of the leaves. He also found that as this plant advanced in age there occurred a decrease in the chlorophyll content of the leaves, about 50 per cent in the 30 to 60-day old plants, and 30 to 40 per cent in the 60 to 80-day old ones. The highest yield of tops of rice plants 30 or 60 days old was obtained from cultures that were supplied with 10.87 grams of ammonium sulfate fertilizer, but 2.72 grams of the fertilizer gave the highest yield of roots for the 30-day old plants. Soriano also noted that by increasing the amount of ammonium sulfate used, the percentage of moisture in the leaves was also increased, but the percentage of ash of this organ always decreased. He also found that the cultures that were fertilized with ammonium sulfate produced plants containing more chlorophyll in the leaves than in those that were fertilized with nitrate of soda. In dry matter and moisture contents, however, the effects of the two fertilizers were found by him to be rather similar.

Libatique (1931) studied the comparative development of the roots of rice plants that were grown in pots containing clay-loam soil to which sulfate of ammonia fertilizer was added in varying amounts. He found that the fertilized plants produced much more numerous but much shorter roots than those from the control cultures. In other words, the control, or unfertilized, plants produced fewer but longer roots than those that were obtained from the fertilized cultures. The size of the root system increased with age, so much so that when that of the 90-day old rice plants was arbitrarily considered as fully developed, or 100 per cent, the root system of the 15-day old plants was found to be only 4 per cent developed; that of 30-day old plants, 22 per cent; that of the 45-day old plants, 40 per cent; that of the 60-day old, 62 per cent; and that of the 75-day old, 80 per cent. As the rice plants grew older, Libatique found that there was a corresponding increase in the yield of top accompanied by a decrease in the yield of roots. The intensity of the green coloring of the rice leaves increased with the increase in ammonium sulfate. The anatomical structures of the roots of the plants were also observed. Libatique found that varying the amounts of ammonium sulfate produced no material alterations in the internal structure of the roots.

Macasaet (1935) tried to determine the N-P_2O_5-K_2O ratio best suited for upland rice when this was grown on tuff soil in pots to which various fertilizers were added. When only ammonium sulfate was added to the cultures containing two plants each, the best growth of the plant and a high yield of grain were obtained with 4.14 grams of the fertilizer or 0.85 gram of N. When the nutritive ingredients from the fertilizer and those from the soil were added together, the best culture was found to contain 27.6 grams of N, 91.2 grams of P_2O_5, and 95.0 grams of K_2O. In other words, the best N-P_2O_5-K_2O ratio was 27.6-91.2-95.0.

The dry matter content of the rice plant was determined by Gile and Carrero (1915). These investigators found that the percentage of dry matter in the green plant did not rise until the plant had begun to form seeds. The composition of ash of an upland rice at different stages of growth was also determined. The results showed that the percentages of K_2O, P_2O_5, and S in the ash of the parts of the plant above the ground decreased with the age of the plant, while the amount of silica increased. The N content of dry matter was found to decrease with age. Kelley and Thompson (1910) found that the rice plant contained a high percentage of nitrogen, phosphorus, and potassium during its early growth, but the percentages of these nutrient materials gradually diminished during the latter development of the plant.

Objects of this study

The main object of this study was to determine how the dry matter and the ash contents of rice plants would be affected by ammonium sulfate fertilizer when this was given to the plants in varying amounts, and to find out if such effects could account for the low yield of grain and its uneven maturity when liberal amounts of the fertilizer were used. Incidentally, the effects upon the general vigor of the plants and the yield of grains by varying the amounts of the fertilizer used were also noted.

Time and place of this study

The culture part of this study was carried out in the experimental yard of the Department of Agricultural Botany. It was begun in June, 1936, and ended in February, 1937. The dry matter and the ash contents of the plants were determined both in the Department of Agricultural Botany and in the Department of Agricultural Chemistry.

MATERIALS AND METHOD

The plant

Upland rice plants, variety Inintiw, were used. The seeds, obtained from the Department of Agronomy, were soaked in water for 24 hours. Then they were planted four seeds to a pot. When the young plants were about one week old, some of them were pulled up, leaving two apparently uniformly developed and healthy plants in each pot.

The solid culture media used

Two types of soil were used, Lipa clay loam and tuff soil; the latter was the typical subsoil of the former. Both were gathered from a field behind the Department of Agricultural Botany. They were thoroughly pulverized in two separate piles, sieved, and mixed, and about seven kilograms of soil were placed in each pot. Samples of the clay loam and of the tuff soil were sent to the Agricultural Chemistry Department for analysis of the N-P_2O_5-K_2O contents. The clay loam soil was found to contain 0.13 per cent of N, 0.43 per cent of P_2O_5, and 0.6 per cent of K_2O, while the tuff soil contained 0.12 per cent of N, 0.35 per cent of P_2O_5, and 0.55 per cent of K_2O. Clay pots with a diameter of 24.5 cm. and a height of 25 cm. each were used as containers in this experiment.

The cultures and the fertilizer used

Ammonium sulfate fertilizer, containing 20.6 per cent N, was used in this study. It was applied to the soil in the pots when the plants were about 5 centimeters in height at the rate of about ¼, ½, ¾, 1, and 1½ tons per hectare. The actual amounts that were added to the cultures were 1.18, 2.35, 3.54, 4.71, and 7.06 grams.

Two main sets of cultures were studied. For convenience in description, these two sets of culture are designated as the clay loam set and the tuff soil set. The first, that is, the clay loam soil set, consisted of six cultures, each of nine pots. At the 30-day harvest, three pots were used, at the 60-day, another three pots, and at the mature harvest, the last three pots. Culture I was the control and contained no ammonium sulfate. The remaining cultures, II, III, IV, V, and VI, contained varying amounts of the fertilizer. Culture II received 1.18 grams of ammonium sulfate; culture III, 2.35 grams; culture IV, 3.54 grams; culture V, 4.71 grams; and culture VI, 7.06 grams. The tuff soil set was run similar to the clay loam set. There

were six cultures in the set. Culture I was the control and received no fertilizer; II received 1.18 grams of ammonium sulfate; III, 2.35 grams; IV, 3.54 grams; V, 4.71 grams; and VI, 7.06 grams.

Care of cultures

The cultures were directly exposed to the sun in the experimental yard of the Department. They were cultivated and watered as often as necessary. Care was taken to keep them free from weeds and destructive insects.

Determination of ash contents

After being dried in an electric oven to constant weight, the tops of the rice plants that were obtained from the different cultures were chopped into small pieces. These were placed in paper bags with

Fig. 1.—Rice plants 30 days old grown on clay-loam soil to which varying amounts of ammonium sulfate were added. Culture I (control) without fertilizer; II, 1.18 grams; III, 2.35 grams; IV, 3.54 grams; V, 4.71 grams; and VI, 7.06 grams of ammonium sulfate. (Data in table 1).

suitable labels. They were then thoroughly mixed, and samples for ash determination were taken from time to time and weighed on an analytical balance. One by one, they were placed in a fine-meshed wire netting, which served as a receptacle, and were burnt over a gas flame. The incinerated samples were then placed in porcelain crucibles and taken to the Department of Agricultural Chemistry for the final and complete ashing in an electric furnace. It took about two hours of continuous burning before each sample could be completely reduced to ashes. The ashes were then kept in crucibles in a desiccator and later on weighed on an analytical balance.

To determine the percentage of ash, the weight of the ash obtained from a sample was divided by the dry weight of the sample. It gave a quotient which when multiplied by 100 gave the percentage

of ash in the sample. To determine the total amount of ash in the tops that were obtained from each culture, the dry weight of the tops was multiplied by the percentage of ash; the product gave the total amount of ash in the tops.

EXPERIMENTS AND RESULTS

Pot cultures tried and results obtained

Two sets of pot cultures of rice were first tried. They were started on June 20, 1936, and consisted of a set of six cultures each. One set was with clay loam soil, and the other with tuff soil. They were photographed and harvested at different times. The first harvest from the two sets was made when the rice plants were 30 days

Fig. 2.—Rice plants 30 days old grown on tuff soil to which varying amounts of ammonium sulfate were added. Culture I (control) without fertilizer; II, 1.18 grams; III, 2.35 grams; IV, 3.54 grams; V, 4.71 grams and VI, 7.06 grams of ammonium sulfate. (Data in table 4).

old (see fig. 1 and 2). The second harvest was made when they were 60 days old (fig. 3 and 4), and the third or the last harvest was made on October 9, 1936, when they were fully mature (see fig. 5 and 6). The experimental data [2] that were obtained are recorded as averages in tables 1 to 3 inclusive for the clay loam set, and 4 to 6 inclusive for the tuff soil set.

Another two sets of pot cultures, also with clay loam and tuff soils, were started on October 19, 1936. These were a repetition of the first two sets. As in the first two, the cultures were photographed and harvested when the plants were 30 days old, 60 days old, and fully mature (see fig. 7 and 8, for the 30-day old plants; fig.

[2] The mass of original data on file in the Department of Agricultural Botany.

9 and 10, for the 60-day old plants; and fig. 11 and 12, for the full grown plants).[3] The last harvest was made on January 30, 1937, and the experimental data are given in tables 7 to 12.[4]

Criteria used

In addition to percentages of ash and total ash contents in samples and in tops that were obtained from the different cultures, other criteria of results are here used. These are (a) number of culms, (b) height of plants, (c) length of roots, (d) fresh weight of tops, (e) dry weight of tops, roots, and of tops and roots. All these criteria of results are used in tables 1 to 12 inclusive. The experimental data under each criterion were obtained as follows:

Number of culms. The culms of the two plants in each pot were counted and recorded at the time of harvest. The average data in the tables were obtained by adding together the number of culms present in the three similar cultures and the sum was then divided by 3.

Height of plants. The data on height of plants were obtained at the time of harvest. Measurements were made from the base of the culms in each culture to the tip of the tallest leaf. The data obtained from the three similar cultures were averaged.

Length of roots. The data under this criterion were obtained as follows: after severing the connection of the tops from the roots, the latter remained in the pot; the roots were then removed from the pots, thoroughly washed and cleaned, and their maximum length measured. The data obtained from the three similar cultures were averaged.

Number of leaves. Data under this criterion were not obtained from the first two sets of cultures. The leaves, however, of the second two sets of cultures were counted before the plants were harvested, and in the case of the mature plants, both the green and the dried leaves in each culture were counted together. The data that were obtained from the three similar cultures were averaged.

Fresh weight of top. The fresh weights of matured rice plants could not be determined, but those for the 30-day and the 60-day old plants were secured. Soon after the tops were severed from the roots, those from each culture were simultaneously weighed, and the average fresh weight of the triplicate cultures was computed.

[3-4] Figures 7-12, and tables 7-12 are on file in the Department of Agricultural Botany.

Dry weight of top. After getting the fresh weights of tops, these were wrapped in paper, labeled, and placed in an electric oven to dry to constant weight. The weight of the dried tops from each culture was determined by means of an analytical balance, and the data obtained from the three similar cultures were averaged.

Dry weight of roots. After their lengths were determined, the roots from each culture were wrapped in paper and labeled. These were then placed in an electric oven to dry. When fully dried, those from the different cultures were separately weighed on an analytical balance.

Fig. 3.—Rice plants 60 days old grown on clay-loam soil to which varying amounts of ammonium sulfate were added. Culture I (control) no fertilizer; II, 1.18 grams; III, 2.35 grams; IV, 3.54 grams; V, 4.71 grams; VI, 7.06 grams of ammonium sulfate. (Data in table 2).

Number of panicles. The number of panicles of the two plants in each culture were counted and recorded just before the mature plants were harvested.

Weight of panicles. At the time of harvest, the panicles were gathered from the different cultures and placed in paper bags properly labeled. They were then left to dry in the sun and later finally dried in an electric oven to constant weight. The weights of panicles from the different cultures were determined on a Cenco balance, and the average weight from three similar cultures was computed.

Dry weight of top and root. The dry weights of tops and roots obtained from each culture were added together. The result constitutes the dry weight of top and root.

DISCUSSION OF RESULTS

Before the merits of the data that have been obtained from this study are considered, it should be pointed out again that the rice used was an upland variety grown in pots containing moist soil, not water saturated. For this reason, and in accordance with the now well-known law of homologous yield curves, the results from this study may be of value to fields under upland conditions, where the soil is usually clay loam, and the moisture content of the soil is never in excess.

Fig. 4.—Rice plants 60 days old grown on tuff soil to which varying amounts of ammonium sulfate were added. Culture I (control) no fertilizer; II, 1.18 grams; III, 2.35 grams; IV, 3.54 grams; V, 4.71 grams; VI, 7.06 grams of ammonium sulfate. (Data in table 5).

It should also be pointed out that in using partly decomposed tuff soil in this study, no intention was in mind to recommend planting of rice in such soil. The object was to use a solid medium sufficiently low in fertility to obtain pronounced effects of the fertilizer. Another object was to obtain experimental data that could be utilized in determining whether or not the N-P_2O_5-K_2O ratio best for the rice plant when grown on tuff soil would be the same or similar to the best ratio of the same fertilizing ingredients when the plant was grown on clay loam soil.

In studying the data on hand, it is deemed best to consider them under the following subtopics: (1) Optimal application of ammonium sulfate fertilizer, (2) Effects of sulfate of ammonia as influenced by age of plant and season, (3) The N-P_2O_5-K_2O ratio best for rice plant, (4) Effects on dry matter, (5) Ash contents as affected by the fertilizer, and (6) Probable causes of harmful effects upon rice plants by liberal use of ammonium sulfate.

Optimal application of ammonium sulfate fertilizer

As may be recalled, mention was made of the profound influence upon the growth and development of the rice plant and on its yield

Fig. 5.—Rice plants, mature, grown on clay-loam soil to which varying amounts of ammonium sulfate were added. Culture I (control) no fertilizer; II, 1.18 grams; III, 2.35 grams; IV, 3.54 grams; V, 4.71 grams; VI, 7.06 grams of ammonium sulfate. (Data in table 3).

of grain by sulfate of ammonia fertilizer. For this reason, the data in tables 1 to 12 inclusive are presented not to prove how good the fertilizer is, for that fact is already known, but rather to afford an opportunity to ascertain the rate of application of ammonium sulfate best suited for upland rice when grown on clay loam or tuff soil in pots in Los Baños. Incidentally, certain data in tables 1 to 15[5] in-

[5] See footnotes (3) and (4), page 452.

clusive were needed in determining the comparative effects upon the dry matter and ash contents of rice plants by varying the amounts of ammonium sulfate fertilizer in pots.

It should, however, be said in passing that as previously observed by Libatique (1931) the intensity of the green of the leaves of the rice plants in the different cultures seemed to increase, though only slightly with more ammonium sulfate. Unfortunately, it must be admitted that the highest amount of the fertilizer used, only 7.06 grams in culture VI, was by no means high enough to show the decided harmful effects upon yield of grain usually observed as a result of a heavy application of the fertilizer. As shown in tables 1 to 12[6] inclusive, the length of the roots was not very unfavorably affected by the highest amount of ammonium sulfate that has been tried. The roots in culture VI were shorter than those in culture V, which received only 4.71 grams of the fertilizer.

The optimal application of ammonium sulfate can be found in tables 1 to 12 inclusive.[7] The two highest records under each criterion in these twelve tables were indicated by H's. From a compilation of the two cultures with the greatest number of H's, the following data were obtained:

TABULATION 1

Table	1, 30-day old.	Cultures IV and V.
	2, 60-day old.	Cultures .... V and VI.
	3, mature.	Cultures .... V and VI.
Table	4, 30-day old.	Cultures IV and V.
	5, 60-day old.	Cultures .... V and VI.
	6, mature.	Cultures .... V and VI.
Table	7, 30-day old.	Cultures V and VI.
	8, 60-day old.	Cultures .... V and VI.
	9, mature.	Cultures .... V and VI.
Table	10, 30-day old.	Cultures IV and V.
	11, 60-day old.	Cultures .... V and VI.
	12, mature.	Cultures .... V and VI.

It may thus be see in tabulation 1 that under the criteria of results employed in this study, cultures V and VI are easily the best in the lot, and of these two, V appears to be the better because in all the twelve tables and irrespective of the age of the plant, this culture was found bearing the largest number of H's. For this reason, it appears that under the conditions of this study and under all the criteria of results here used, 4.71 grams of ammonium sulfate should

[6,7] See foot-notes (3) and (4), page 452.

be considered as the optimal application of this fertilizer for rice. The 7.06 grams application, however, may be considered also as sufficiently good for the plant. In fact, it will be shown that in terms of dry weight of the plants and number of panicles, (criteria which are much more dependable than the mere height of the plant and length of roots), culture VI which received 7.06 grams of the fertilizer was found better than culture V.

Effects of sulfate of ammonia as influenced by age of plant and season

The data in tables 1 to 3 and 7 to 9 [8] under columns (*a*) *number of culms* and (*b*) *fresh weight of tops* are to be further considered.

Fig. 6.—Rice plants, mature, grown on tuff soil to which varying amounts of ammonium sulfate were added. Culture I (control) on fertilizer; II, 1.18 grams; III, 2.35 grams; IV, 3.54 grams; V, 4.71 grams; VI, 7.06 grams of ammonium sulfate. (Data in table 6).

This time, the object will be to see if the effects of sulfate of ammonia were influenced by the age of the rice plants and by seasons. The *actual values* under the two criteria of results here considered are reduced to *relative values*. The actual value for the control plant was arbitrarily considered as 1.0, and the rest of the actual values under each criterion of results were reduced to their respective relative values accordingly. The results are shown in the following ta-

[8] Tables 7 and 8 are on file in the Department of Agricultural Botany.

bulation. The data under columns *a* were obtained from cultures of rice with clay loam soil, started on June 20, 1936, while those under columns *b* were obtained from similar cultures but started on October 19, 1936. From the standpoint of season, the June planting may be considered as the more favorable or more appropriate for the rice plant than the October planting.

TABULATION 2

CULTURE NO.	NUMBER OF CULMS						FRESH WEIGHT OF TOP			
	30-day old		60-day old		mature		30-day old		60-day old	
	a	b	a	b	a	b	a	b	a	b
I	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
II	3.5	2.3	2.3	1.3	2.0	1.9	5.5	2.3	4.6	3.1
III	4.2	3.1	2.7	2.6	2.5	2.2	6.8	3.1	9.2	5.5
IV	5.5	3.8	3.6	3.0	2.4	2.4	14.0	4.7	10.4	6.1
V	6.2	4.9	4.8	3.8	3.4	2.8	12.1	4.5	13.8	8.7
VI	5.7	5.8	4.3	4.1	3.9	3.6	12.1	4.1	17.7	9.5

a. Effects of the fertilizer as influenced by the age of the plant. As shown in tabulation 2, it appears that on the basis of the relative value of the number of culms for culture I, the unfertilized culture, the effects of a certain amount of the fertilizer on the 30-day old rice plants were much more pronounced than those of a similar amount upon the 60-day old or the mature plants. In the case of the mature plants, the number of culms actually diminished because some of the suckers along the sides of each hill or plant had died on reaching full maturity. Consequently, when the culms of the mature plants were counted at the time of harvest some of the side shoots or suckers that were present when the plants were 60 days of age were found missing. This observation accounts for the apparent decrease in the number of culms in mature plants. But in actual number of culms at their respective times of harvest, the 30-day old plants that received a certain amount of the fertilizer had always fewer culms than the corresponding 60-day old plants. In other words, the rate of tillering of the 30-day old rice plants was very much faster in the fertilized cultures than in the control or the unfertilized cultures. And, as the plants grew older, that is, at the age of 60 days, the control plants had tillered more, at least in proportion to the rate of production of tillers in the corresponding fertilized cultures.

Another feature worth mentioning is the influence upon tillering of the amount of ammonium sulfate. In tabulation 2 and in tables 1 to 3 and 7 to 9 [9] the fact may be seen that when grown on clay loam soil, the rice plants produced more tillers when more ammonium sulfate was used. This generalization, however, holds true

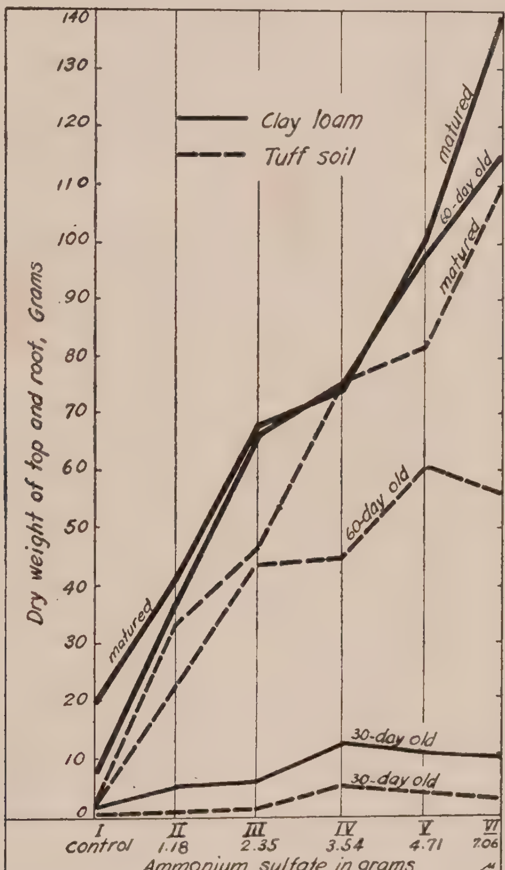

Fig. 13.—Graph showing yield of top and root at different stages of growth of the rice plants supplied with varying amounts of ammonium sulfate. (Experiment from June 20, 1936, to October 9, 1936).

only up to the 4.71 grams application of the fertilizer and for the 30-day old plants. For, at a later harvest, when the plants were 60 days of age or when fully mature, in some cases, the 7.06 grams application produced plants with a slightly smaller number of culms.

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[9] See footnote (8), page 457.

Tabulation 2 also shows, with a few exceptions, that the fresh weight of tops of the 30-day and 60-day old plants increased with the increase of ammonium sulfate fertilizer.

b. Effects of the fertilizer as influenced by season or time of planting. It may be seen in tabulation 2 that, with only one exception, the June plantings, the results of which are indicated under columns *a*, produced plants with more culms than those obtained from the corresponding cultures (under *b*) in the October plantings. In other words, the degree of tillering of the rice plants used in this study was influenced not only by age of the plant and the amount of ammonium sulfate fertilizer, but also by the time and season of planting.

The N-P_2O_5-K_2O ratio best for rice

In order to be able to select the best cultures under the different criteria of results employed, the following tabulation is made. The data in this were obtained from tables 1 to 12, inclusive.[10]

TABULATION 3

SOIL USED	AGE OF PLANTS AT HARVEST	REPLICATION	NUMBER OF H'S IN CUTURE NO. I	II	III	IV	V	VI
clay loam	30-day old	a			1 H	5 H	5 H	3 H
		b			1 H	3 H	7 H	5 H
	60-day old	a				1 H	7 H	6 H
		b				1 H	8 H	7 H
	mature	a				1 H	8 H	7 H
		b				1 H	8 H	9 H
	Total				2 H	12 H	43 H	37 H
tuff soil	30-day old	a		1 H	1 H	6 H	6 H	
		b		2 H	2 H	6 H	6 H	
	60-day old	a		1 H	2 H	1 H	6 H	7 H
		b				2 H	6 H	5 H
	mature	a				1 H	8 H	7 H
		b				2 H	9 H	7 H
	Total			4 H	6 H	18 H	41 H	26 H

When the number of H's under each culture were added, it was found that culture V received the larger number of H's, with culture VI coming next. These two cultures are again shown as the best in the sets of cultures tried. Culture V, which contained 7000 grams of clay loam soil, received from the 4.71 grams of ammonium sulfate

[10] See footnotes (3) and (4), page 452.

0.97 gram of N. If this amount of N is added to the N-P_2O_5-K_2O contents of the clay loam[11] soil, the results would be 10.07 grams of N, 30.1 grams of P_2O_5, and 42 grams of K_2O. Therefore, the N-P_2O_5-K_2O ratio best for the rice plant was found to be approximately 10-30-42.

In tabulation 3 it may also be seen that, under the criteria of results here employed, for tuff soil the largest number of H's falls also on culture V. This culture received also 4.71 grams of ammonium sulfate, or 0.97 gram of N. If this amount of N is added to the N-P_2O_5-K_2O contents of the tuff soil,[12] the results would be 9.37

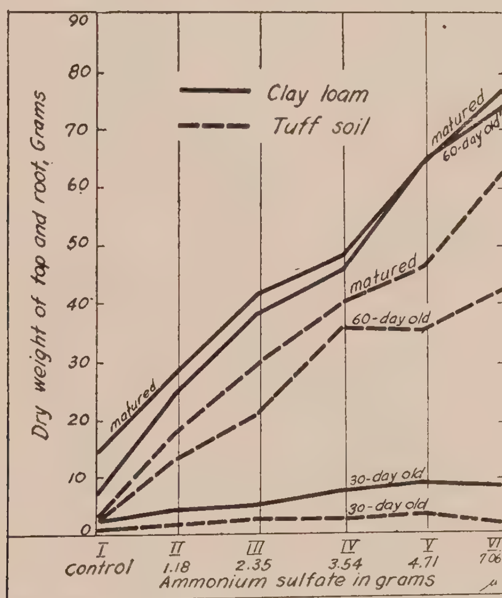

Fig. 14.—Graph showing yield of top and root at different stages of growth of the rice plants supplied with varying amounts of ammonium sulfate. (Experiment from October 19, 1936, to January 30, 1937).

grams of N, 24.5 grams of P_2O_5, and 38.5 grams of K_2O. It is surprising that the poorer or less fertile soil (the tuff soil) did not require more fertilizer to give the best growth of the rice plant.

Culture V turned out as the best culture when and only when the data under all the criteria of results in tables 1 to 12[13] inclusive were considered. If the comparative merits of the culture media

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[11-12] The chemical compositions of this soil are given on page 449.
[13] See footnotes (3) and (4), page 452.

used, however, were to be reckoned in terms of the data on number and dry weight of panicles, and on dry weight of tops and roots, the results would show differently; i. e., that culture VI, which received the highest amount of ammonium sulfate came out as the

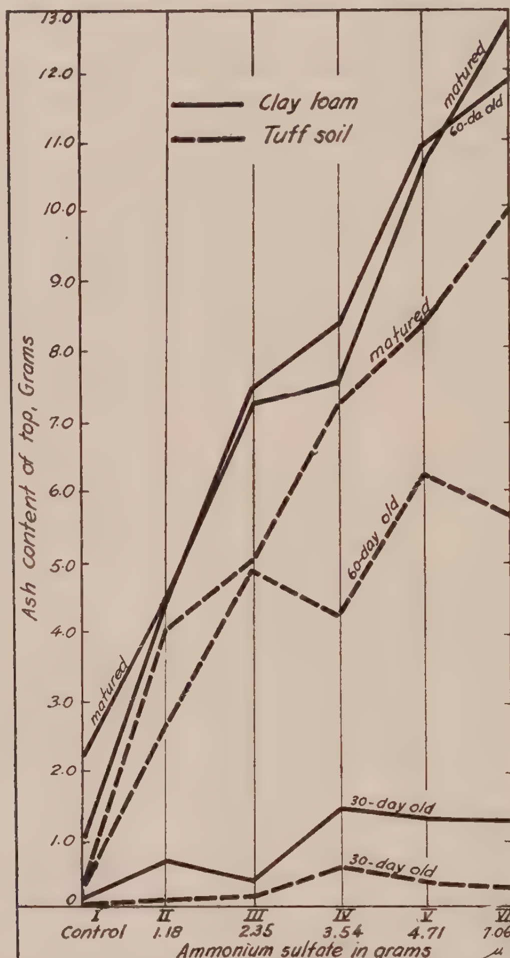

Fig. 15.—Graph showing the total ash content of top at different stages of growth of the rice plants supplied with varying amounts of ammonium sulfate. (Experiment from June 20, 1936, to October 9, 1936).

best for both the clay loam and the tuff soil. The data in tabulation 4 bear out this contention. In this the better results, either for culture V or for culture VI, are indicated by H's.

TABULATION 4

CULTURE NO.	PANICLES				DRY WEIGHT OF					
	Number		Dry weight		Top		Root		Top and root	
	a	b	a	b	a	b	a	b	a	b
Clay loam			*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
V	27.3	17.3	34.7 H	22.4	84.0	52.3	17.2	12.3	101.2	64.6
VI	31.0 H	23.3 H	33.7	23.5 H	116.0 H	60.3 H	23.9 H	16.9 H	139.9 H	77.2 H
Tuff soil										
V	23.0	16.0	32.6 H	20.9 H	64.3	36.8	18.4	10.1	82.7	46.9
VI	26.0 H	17.6 H	31.4	20.6	89.9 H	50.9 H	22.0 H	11.7 H	111.8 H	62.6 H

Note: The *a* refers to the June planting; *b*, to the October planting.

In tabulation 4 it may be seen that most of the H's fall on culture VI, so that except in dry weight of panicles, culture VI is superior to V. Culture VI received 7.06 grams of ammonium sulfate, or 1.45 grams of N. As this was the highest amount tried, it might be possible that an increase of the fertilizer might give even better results. Evidently, Soriano (1934) found that the highest yields of tops of rice plants 30 or 60 days old were obtained from cultures that were supplied with 10.87 grams of ammonium sulfate. If the fertilizing ingredients of the clay loam were to be computed and added to the amount of N from the fertilizer, the results would be as follows: 10.55 grams of N, 30.1 grams of P_2O_5, and 42 grams of K_2O. And the fertilizing ingredients in culture VI with tuff soil would be 9.85 grams of N, 24.5 grams of P_2O_5, and 38.5 grams of K_2O.

Effects on dry matter

For convenience of study, the data on dry weight of top and root, or the whole plant shown in tables 1 to 6 inclusive, are graphed in figure 13. These data were obtained from the rice plants that were grown in pots containing either clay loam or tuff soil, from the June planting. Examination of the graphs referred to will show that as the rice plant grew older its body contained more dry matter. The graphs also show that as a general rule, more dry matter was produced as the amount of the fertilizer was increased. It appears, therefore, that application of ammonium sulfate was conducive to the production of dry matter, and within the limits of this study, the greater the application of the fertilizer, the greater was the response of the rice plants in producing dry matter in tops and roots. It should be noted that these generalizations, interesting as they may be, are applicable only to the older rice plants studied, that is, to those of 60 days of age and the mature ones. In the case of the 30-day old plants, however, the effects upon the production of dry matter by increasing the amount of the fertilizer were relatively slight and gradual. The graphs for the 30-day old plants in figure 13 bear this out.

The data under the dry weight of top and root were similarly graphed (see fig. 14). These data were obtained from the cultures that were started on October 19, 1936, and a repetition of a similar set of cultures that had been tried before. Examination of figure 14 once more reveals the fact that as the rice plants grew older and as

they received more ammonium sulfate fertilizer in pot cultures, more dry matter was produced. Figure 14 also shows that the use of ammonium sulfate fertilizer did not result in a marked increase in the amount of dry matter of the 30-day old rice plants.

Ash contents as affected by the fertilizer

The data on total ash contents of the tops of the rice plants at their different stages of growth recorded in tables 13 to 16 inclusive [14]

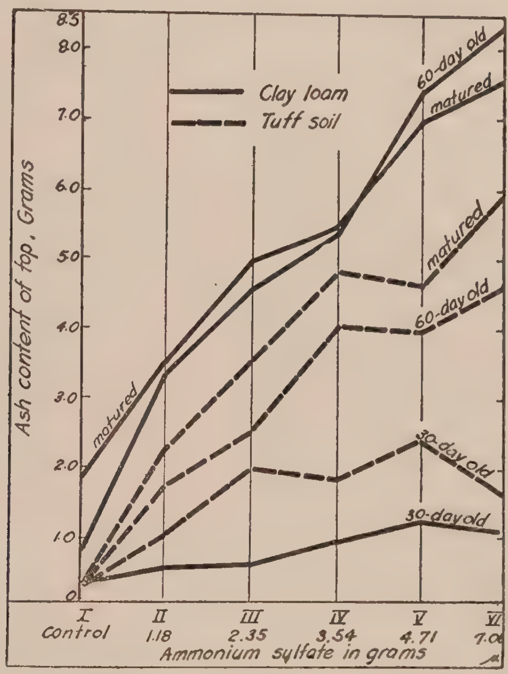

Fig. 16.—Graph showing the total ash content of top at different stages of growth of the rice plants supplied with varying amounts of ammonium sulfate. (Experiment from October 19, 1936, to January 30, 1937).

are graphed in figures 15 and 16. Figure 15 shows the ash content of the plants from the June planting, while figure 16 shows those for the October planting.

As may be expected, the graphs show that the ash content of tops increased with the amounts of ammonium sulfate fertilizer used

[14] Only tables 13 and 15 are published herein; the others are on file in the Department of Agricultural Botany.

and with the age of the rice plant. Marked material increases in ash content of tops appear to have occurred in the older rice plants—the 60-day old and in the mature ones as well. The rate of increase of the ash contents in tops of the 30-day old plants as influenced by increase of the fertilizer used were conspicuously gradual or slow. The graphs in figures 15 and 16 also show that in spite of the fertilizer used, the production or accumulation of ash in the leaves and stalks of the older rice plants was materially affected by the time of planting. The tops of the older plants from the June planting contained much more ash than those from the plants that were started in cultures in October. In the case of the 30-day plants, however, the cultures that were started in June produced less ash than the corresponding cultures that were started in October.

More interesting findings in this study in connection with the percentage of ash on the basis of the dry weight may be seen in figures 17 and 18. The graphs in these figures are built with certain data in tables 15 and 16,[15] and show vividly the gradual decrease of the percentage of ash of tops as the amount of ammonium sulfate fertilizer used was increased. The graphs referred to also show that, in a general way, the tops of 30-day old rice plants had more ash per gram basis than those of the 60-day old plants, and that the 60-day old plants produced more ash per gram basis than the fully mature plants. Therefore, it appears safe to conclude that the percentage of ash in tops diminished with the age of the rice plants. This finding is in accord with the report of Duggar (1911) to the effect that, in general, ash and nitrogen are present in the young plant in relatively greater quantities than in the latter stages of growth. Palladin (1918) made a similar observation to the effect that the tissues richer in ash are those in which living cells are most numerous. Under the conditions of this study, it seems also safe to conclude that the percentage of ash in tops diminished with the amount of ammonium sulfate fertilizer used, and thus an earlier report of Soriano (1934) is confirmed.

Probable explanation for harmful effects upon rice plants of liberal use of ammonium sulfate

By harmful effects upon rice plants is meant the late flowering and consequently late fruiting, the comparatively low yield of grain, and the variable time of ripening of grains—all three being features

[15] Only table 15 is published herein; table 16 being a repetition of table 15 is on file in the Department of Agricultural Botany.

that are undesirable in rice culture. These features appeared in the present study, but were not very pronounced because the largest amount of the fertilizer tried was only 7.06 grams per pot culture of two plants. The data that have been obtained showing variations of ash content (in terms of percentage on the basis of the dry weight of tops) of the older plants grown in the different cultures tested,

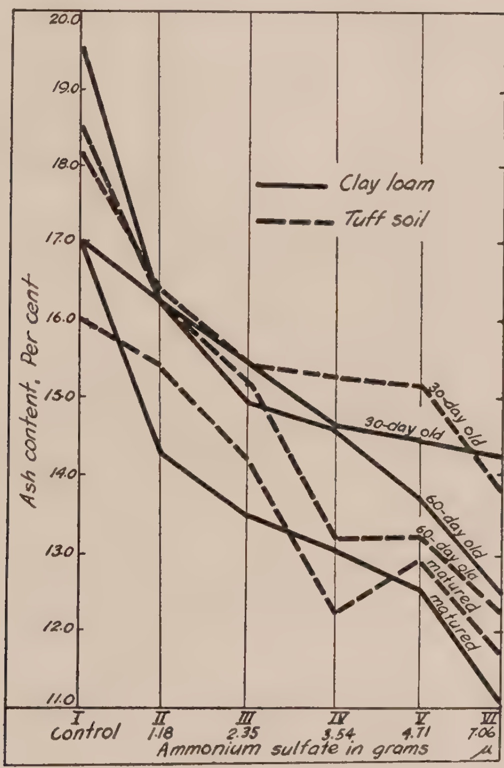

Fig. 17.—Graph showing percentages of ash of top at different stages of growth of the rice plants supplied with varying amounts of ammonium sulfate. (Experiments from June 20, 1936, to October 9, 1936).

however, seem to be of value in explaining the apparent harm done to the plant by liberal application of the fertilizer. Hence, it is deemed possible to consider the question at this time.

The ammonium sulfate fertilizer contains ammoniacal nitrogen which is well known to favor the production of foliage leaves. Since the basic food of the plant is produced in the leaves, these organs

have a better chance of appropriating it for their own use—for growth and development. It thus appears that a liberal application of ammonium sulfate would naturally tend, as it evidently did, to produce a heavy growth of culms and leaves at the expense of the underground structures, the roots. As shown by the data on the amount of chlorophyll in the leaves, as per analyses made by Soriano

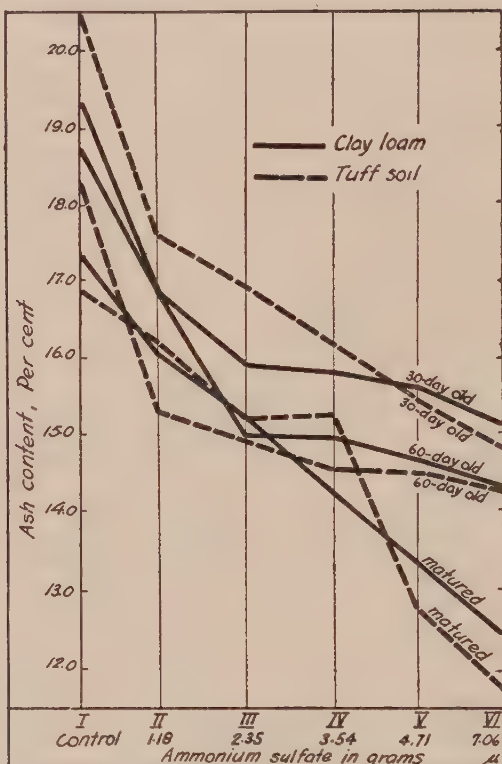

Fig. 18.—Graph showing percentages of ash of top at different stages of growth of the rice plants supplied with varying amounts of ammonium sulfate. (Experiment from October 19, 1936, to January 30, 1937).

(1934), it is possible to visualize that no little amount of carbohydrate food was consumed for the production of chlorophyll as the amount of the fertilizer used was increased. It might also be suspected that the food that reached the roots was not sufficient to bring about the normal growth and development of the latter; hence, shorter roots were produced.

A decrease in the length of the roots of the heavily fertilized plant would obviously result in a correspondingly greater decrease of the absorbing surface. Such a decrease, other conditions remaining the same, would produce a greatly diminished rate of intake of soil nutrients in proportion to the amount of carbohydrate produced by the leaves. Evidently this was the case, as shown by the progressive decrease in the percentage of ash (based on the dry matter of the tops of the plant) as the plant grew older, and as the amount of fertilizer used was diminished.

For these reasons, it may tentatively be concluded that the delay in fruiting and the lack of uniformity of ripening of the grains produced ultimately were caused by the absence from the leaves of the full-grown rice plants of the required carbon-nitrogen ratio, which other workers found so essential to bring about production of fruits in certain plants.

Determination of the carbon-nitrogen content of the leaves of the rice plants supplied with varying amounts of ammonium sulfate fertilizer might throw more light on the subject. It might also help explain the peculiar harmful effects of liberal applications of the fertilizer upon the yield of grain.

SUMMARY AND CONCLUSIONS

In this study, upland rice plants (variety Inintiw) were grown on clay-loam and on tuff soils in pots to which ammonium sulfate fertilizer in varying amounts was added. Under the conditions of this study and from the results that were obtained, it seems permissible to draw the following conclusions:

1. As the amount of ammonium sulfate fertilizer was increased, a corresponding increase in intensity of the green color of the leaves took place—a result which confirmed Soriano's (1934) finding.

2. Under all the criteria of results employed, 4.71 grams of ammonium sulfate should be considered as the optimal application for the rice plant. But in terms of dry weight and number of panicles, 7.06 grams were the best.

3. The degree of tillering was influenced, not only by the age of the plant and the amount of ammonium sulfate fertilizer used, but also by the time and season of planting.

4. In terms of all the criteria of results employed, the best N-P_2O_5-K_2O ratio for rice plants was found to be approximately 10-30-42 for clay loam soil, and 9.37-24.5-38.5 for tuff soil. But in

terms of dry weight and number of panicles, the best N-P_2O_5-K_2O ratio for the rice plant on clay-loam soil was 10.55-30.1-42, while on stuff soil it was 9.85-24.5-38.5.

5. As the rice plants grew older and as they received more ammonium sulfate fertilizer, more dry matter was produced. Increased application of the fertilizer, however, did not result in a marked increased in the amount of dry matter of the 30-day old rice plants.

6. The ash content of tops increased with the age of the rice plant and with the amounts of ammonium sulfate fertilizer; more marked increases in ash contents of tops occurred in the older plants.

7. The percentage of ash in tops diminished with age of the rice plant and with the amount of ammonium sulfate fertilizer used and thus confirmed an earlier work of Soriano (1934).

8. It may be concluded tentatively that the delay in fruiting and the lack of uniformity of ripening of the grains produced were caused by the presence in the leaves of an insufficient amount of mineral and nitrogenous salts in proportion to the amount of carbohydrate that the leaves of the older plants can produce photosynthetically. Thus, the carbon-nitrogen ratio found so essential for the production of fruits in certain plants might be wanting in full-grown rice plants liberally fertilized with sulfate of ammonia.

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TABLE 1

Average data obtained from 60-day old rice plants[a] *grown on clay loam soil in pots to which varying amounts of ammonium sulfate fertilizer were added*

(EXPERIMENT FROM JUNE 20, 1936 TO JULY 27, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	NUMBER OF CULMS	HEIGHT OF PLANTS AT HARVEST	LENGTH OF ROOTS	FRESH WEIGHT OF TOP	DRY WEIGHT OF		
						top	root	top and root
	grams		*cm.*	*cm.*	*grams*	*grams*	*grams*	*grams*
I	Control	4.6	42.0	26.1	2.3	0.73	0.36	1.09
II	1.18	16.3	65.0	34.1	12.7	4.47	1.09	5.56
III	2.35	19.3	66.1	50.5	15.7	5.16	1.05	6.21
IV	3.54	25.3	69.1	41.8H	32.2H	10.36H	2.08H	12.44H
V	4.71	28.6H	71.5H	38.5	27.9	9.35H	1.65H	11.00H
VI	7.06	26.3H	73.3H	30.1	29.0H	8.95	1.59	10.54

[a] Two plants in each culture.

TABLE 2

Average data obtained from 30-day old rice plants[a] *grown on clay loam soil in pots in which varying amounts of ammonium sulfate fertilizer were used*

(EXPERIMENT FROM JUNE 20, 1936 TO AUGUST 27, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	NUMBER OF CULMS	HEIGHT OF PLANTS AT HARVEST	LENGTH OF ROOTS	FRESH WEIGHT OF TOP	DRY WEIGHT OF		
						top	root	top and root
	grams		*cm.*	*cm.*	*grams*	*grams*	*grams*	*grams*
I	Control	8.7	58.2	29.1	15.5	5.0	2.2	7.2
II	1.18	20.0	74.1	42.3	71.4	26.4	11.2	37.6
III	2.35	23.3	88.8	50.5	140.1	50.3	15.5	65.8
IV	3.54	31.3	95.0	64.6H	161.1	58.0	16.1	74.1
V	4.71	34.7H	101.3H	63.1H	213.8H	79.3H	19.2H	98.5H
VI	7.06	37.7H	109.3H	39.0	274.9H	95.9H	20.3H	116.2H

[a] Two plants in each culture.

TABLE 3

Average data obtained from mature rice plants[a] grown on clay loam soil in pots to which varying amounts of ammonium sulfate fertilizer were added

(EXPERIMENT FROM JUNE 20, 1936 TO OCTOBER 9, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	NUMBER OF CULMS	HEIGHT OF PLANTS AT HARVEST	LENGTH OF ROOTS	PANICLES		DRY WEIGHT OF		
					number	weight	Top	Root	Top and root a
	grams		*cm.*	*cm.*		*grams*	*grams*	*grams*	*grams*
I	Control	8.6	86.8	38.1	7.6	8.7	12.9	6.3	19.2
II	1.18	17.0	100.5	42.0	15.0	17.0	30.9	10.4	41.3
III	2.35	21.6	124.5	47.6	18.6	22.0	53.4	14.5	67.9
IV	3.54	20.6	123.2	54.0H	17.3	29.1	57.9	15.8	73.7
V	4.71	29.0H	133.0H	59.0H	27.3H	34.7H	84.0H	17.2H	101.2H
VI	7.06	33.3H	140.3H	51.1	31.0H	33.7H	116.0H	23.9H	139.9H

[a] Two plants in each culture.

TABLE 4

Average data obtained from 30-day old rice plants grown on tuff soil in pots to which varying amounts of ammonium sulfate fertilizer were added

(EXPERIMENT FROM JUNE 20, 1936 TO JULY 27, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	NUMBER OF CULMS	HEIGHT OF PLANTS AT HARVEST	LENGTH OF ROOTS	FRESH WEIGHT OF TOP	DRY WEIGHT OF		
						Top	Root	Top and root
	grams		*cm.*	*cm.*	*grams*	*grams*	*grams*	*grams*
I	Control	3.3	31.6	25.1	1.6	0.37	0.27	0.64
II	1.18	4.6	46.5	49.1H	2.9	0.75	0.28	1.03
III	2.35	6.6	51.6	38.1H	3.6	1.27	0.47	1.74
IV	3.54	16.0H	57.0H	35.6	11.1H	3.95H	1.29H	5.24H
V	4.71	13.6H	54.3H	30.0	9.4H	3.05H	0.95H	4.00H
VI	7.06	11.3	52.3	26.1	8.1	2.49	0.84	3.33

TABLE 5

Average data obtained from 60-day old rice plants grown on tuff soil in pots to which varying amounts of ammonium sulfate fertilizer were added

(EXPERIMENT FROM JUNE 20, 1936 TO AUGUST 27, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	NUMBER OF CULMS	HEIGHT OF PLANTS AT HARVEST	LENGTH OF ROOTS	FRESH WEIGHT OF TOP	DRY WEIGHT OF		
						Top	Root	Top and root
	grams		*cm.*	*cm.*	*grams*	*grams*	*grams*	*grams*
I	Control	4.6	45.2	25.5	3.4	1.4	0.8	2.2
II	1.18	14.0	74.0	52.8	42.6	16.7	6.9	23.6
III	2.35	20.6	85.5	60.3H	82.6	31.5	12.0H	43.5
IV	3.54	24.3	91.8	62.3H	98.5	33.1	12.0H	45.1
V	4.71	33.0H	93.2H	47.5	133.6H	47.3H	14.1H	61.4H
VI	7.06	27.6H	96.6H	34.0	134.0H	49.9H	10.4	56.3H

TABLE 6

Average data obtained from mature rice plants grown on tuff soil in pots to which varying amounts of ammonium sulfate fertilizer were added

(EXPERIMENT FROM JUNE 20, 1936 TO OCTOBER 9, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	NUMBER OF CULMS	HEIGHT OF PLANTS AT HARVEST	LENGTH OF ROOTS	PANICLES		DRY WEIGHT OF		
					number	weight	Top	Root	Top and root [a]
	grams		*cm.*	*cm.*		*grams*	*grams*	*grams*	*grams*
I	Control	2.3	64.8	27.5	2.3	2.4	2.3	0.6	2.9
II	1.18	12.3	98.8	41.0	11.0	9.9	26.4	7.5	33.9
III	2.35	20.0	113.3	46.3	16.3	18.9	35.9	11.2	47.1
IV	3.54	23.6	124.2	50.5H	21.3	28.6	59.4	16.8	76.2
V	4.71	24.6H	126.3H	54.8H	23.0H	32.6H	64.3H	18.4H	82.7H
VI	7.06	32.3H	125.0H	39.1	26.0H	31.4H	89.8H	22.0H	111.8H

[a] Panicles not included.

TABLE 13

Average ash contents of top of 30-day, 60-day, and mature rice plants [a] grown on clay loam soil in pots to which varying amounts of ammonium sulfate fertilizer were added

(EXPERIMENT FROM JUNE 20, 1936 TO OCTOBER 9, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	30-DAY OLD		60-DAY OLD		MATURE PLANT	
		Amount of ash in dry sample	Ash content of top	Amount of ash in dry sample	Ash content of top	Amount of ash in dry sample	Ash content of top [b]
	grams	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*grams*
I	Control	19.62	0.14	17.16	0.85	17.02	2.19
II	1.18	16.24	0.71	16.24	4.31	14.31	4.42
III	2.35	15.52	0.44	14.93	7.50	13.49	7.20
IV	3.54	14.63	1.49	14.61	8.39	13.02	7.52
V	4.71	14.52	1.35	13.78	10.91	12.59	10.57
VI	7.06	14.31	1.27	12.51	11.92	10.99	12.70

[a] Two plants in each culture.
[b] Panicles not included.

TABLE 15

Average ash contents of top of 30-day, 60-day, and mature rice plants grown on tuff soil in pots to which varying amounts of ammonium sulfate fertilizer were added

(EXPERIMENT FROM JUNE 20, 1936, TO OCTOBER 9, 1936)

CULTURE NO.	AMOUNT OF AMMONIUM SULFATE FERTILIZER USED	30-DAY OLD		60-DAY OLD		MATURE PLANT	
		Amount of ash in dry sample	Ash content of top	Amount of ash in dry sample	Ash content of top	Amount of ash in dry sample	Ash content of top [a]
	grams	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*grams*
I	Control	18.28	0.05	18.57	0.25	16.08	0.36
II	1.18	16.47	0.12	16.24	2.68	15.42	4.02
III	2.35	15.56	0.19	15.27	4.88	14.24	5.04
IV	3.54	15.31	0.59	13.23	4.28	12.24	7.23
V	4.71	15.27	0.46	13.25	6.27	12.94	8.30
VI	7.06	13.85	0.34	12.28	5.63	11.64	9.97

[a] Panicles not included.

ABSTRACT[1]

The cost of production of soy bean (*Glycine hispida*). JUAN B. ROZUL. *(Thesis presented for graduation, 1932, with the degree of Bachelor of Agriculture No. 675; Experiment Station contribution No. 1192.)*—With the object of determining its cost of production under Los Baños conditions, the author worked on the culture of soy bean. The seeds used were obtained from the farm crops division, Department of Agronomy, and selected from the crop of 1930-1931. Two sets of plantings were made in the College Experiment Station. The wet-season culture was planted on May 27, 1931, and the dry-season one on October 27 and 28, 1931. The distances between the plants for both cultures were the same, one meter between the rows and one-half meter between the hills in each row. All necessary weeding, cultivation, and care were given to both crops.

The author made observations on the rate of seeding, amount of seeds and straws harvested, and the various factors that affect cost of production and crop yield. The cost of production, as computed by the author, included the cost of all materials used, labor (including the author's time), land rent, and the depreciation and interest of implements used.

The following conclusions were found:

1. The cost of production per hectare was ₱86.90 for the wet-season culture and ₱62.39 for the dry season.

2. The cost of production per cavan of seeds was ₱5.19 for the wet-season crop and ₱15.07 for the dry season.

3. Yields of 16.73 cavans of seeds and 2,900 kilograms of straw per hectare were obtained from the wet-season crop. From the dry-season culture, 4.14 cavans of seeds and 270.5 kilograms of straw were obtained per hectare.

4. Additional cultivation, hand weeding, and the uncertainty of weather conditions raised the cost of production per hectare of the wet-season crop.

5. Uncertainty of weather conditions delayed some field operations and thus raised the cost of production.

[1] Abstract prepared as part of the required theme work in English 3a, College of Agriculture.

6. Weeds grew so vigorously and abundantly during the wet season that the cost of weeding was rather high.

7. It cost ₱10.00 to harvest a hectare of soy bean in the wet season and ₱5.68, in the dry season.

8. The rain increased the expenses of threshing and drying.

9. The wet-season crop matured at the age of 154 days and the dry-season crop, at the age of 95 days.

—*Abstract by Felix J. Madrid*

COLLEGE AND ALUMNI NOTES

The faculty and employees of the College of Agriculture held a surprise "Nepa" party at the Molawin Hall in honor of the tenth anniversary of the deanship of Professor B. M. Gonzalez. Later in the evening, the students staged a torch parade. Doctor Gonzalez has been dean of this College since August 27, 1927.

Two senior students, Lorenzo P. Zialcita and Remberto Z. Ver, were recently elected associate members of the Society for the Advancement of Research.

The following papers were read at the monthly meeting of the Los Baños Biological Club on August 26:

Dr. Valeriano C. Calma. The comparative effects of ammonium sulfate and legumes on the yield of sugar cane.

Dr. L. B. Uichanco. Insects in Philippine folklore.

His Serene Highness Prince Rajada-Bhisek Sonakul, director of education of the Kingdom of Siam, was guest speaker at a special convocation in the College auditorium on August 30.

Mr. U. Kojima, of the Ohta Development Company, Mr. S. Eihara, cotton expert from Japan, and Mr. T. Honda, of Formosa, were on the campus on August 19 for a technical consultation with scientists at the College about agricultural problems in Davao.

LOS BAÑOS AND VICINITY ONE HUNDRED AND FORTY YEARS AGO [1]

On January 7 [1800] we left Tanauan for Calamba by the same road we had taken in the evening on our way to Batangas province. Crossing the river, we came across a forest full of trees, which are called *madrecacao* [*Gliricidia sepium* (Jacq.) Steud.]. The tree is very beautiful; it sheds the leaves in autumn and by January it bursts into bloom which is agreeable to see. The fruit is a pod filled with small seeds, which considerably multiply the species, because as the shell dries, it collapses forcibly, scattering the seeds and producing a forest within a few years. The wood of this tree is resistant to water, but, exposed to sunlight, it deteriorates easily. However, the Indians utilize it to fence their gardens and corrals, but because only a little is used this way, the trees increase so much that they can be detrimental in the provinces, owing to the indolence of the Indians. These natives are so easy-going that, when the trees crowd their houses, they would rather transfer the houses to another site than take the trouble to pull the trees out. More diligent Indians clear some pieces of land occupied by these trees and pull out the roots and burn them, to make a garden or field, which turns out to be very fertile. Had it not been for this diligence, a large part of the province would have been a forest.

After walking half a league, we reached the town of Santo Tomas. The way was level and very enjoyable because of the song birds and the numerous monkeys that shouted at us from the trees. They looked somehow as though they were treating us to a joke, for which they paid highly, because they were given a salvo of shots that made them scream for a long time. In the rainy season this road becomes impassable on account of the big mud pools which the carabaos make by their heavy weight and, because sunlight is shut off by the thick branches, it takes a long time to dry. We found no mud, but there were still some vestiges of the mire that had prevailed in the wet season.

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[1] Translated by L. B. Uichanco from MARTINEZ DE ZUÑIGA, JOAQUIN. 1893 (written about 1800). Estadismo de las Islas Filipinas. Madrid: W. E. Retana, editor. 1, chapter 9, in part: 175–185.

THE PHILIPPINE AGRICULTURIST, VOL. XXVI, No. 6, NOVEMBER, 1937.

The town of Santo Tomas, which we had not seen because of having previously passed through it at night, offered small comfort; a poor church of bamboo and leaves and some thirty or forty houses were all that we saw. There were not more than about 500 tax-payers scattered in the fields, like the other Indians in the province of Batangas, to which the town belongs, and from whom they do not differ in all their ways and customs. The first thing that we found worth noting, after leaving Santo Tomas, was the gorge of Biga, which had caused us such fright when we crossed it at night. Having since become used to passing other gorges with which this province abounds, this one did not now appear so terrifying, although it is the most dangling and longest of all we had ever seen in the entire trip. After passing the gorge, we found ourselves on an extensive plain at a very high elevation, which afforded a very pleasant and picturesque view. At a short distance to the west could be seen Mount Suñgay and to the east, Mount Maquiling, which shielded a a little the objects on both sides; but to the south, Taal Volcano and the entire province of Batangas could be made out, and to the north, all of Laguna de Bay and the towns around it. So delightful did this site appear to some, that they said Manila should have been located here; but in the Philippines all the towns are built, not where reason dictates, but where chance happens to place them. On this vast plain were not more than four or five little huts, a fact which shows clearly the poverty of those living there, who find themselves obliged to give quarters to highway robbers. If this population should increase, it might serve as a great convenience to travellers; but so long as it does not grow to a point where it would be stronger than the robbers, I believe it constitutes a source of danger rather than of utility. These houses had been built in these parts a short time before, and thus the Indians call the place *Bagumbayan*, which means *new town*. It belongs to Santo Tomas and it is the last habitation on this side of the province of Batangas.

At the beginning of the downgrade on the slope, the province of Laguna also begins. Nothing worth noting was found in all these places until the brow of the slope was reached, where we could see the ruins of a gunpowder factory that had been burnt some years previously and had not been rebuilt, because the land was unhealthful and the Spaniards very commonly suffered there from tertian fever. From the gunpowder factory to Calamba is a distance of over a mile through a road that traverses a plain which at one time was rice land, but which is now merely occupied by guavas and several kinds

of shrubs. Guava is a tree which came from New Spain [Mexico]; it produces a pear-like fruit which is filled with small seeds. It is not of a very delicate flavor, but the Indians enjoy it, especially the children, and an excellent sweet is made with it. In the neighborhood of Manila the Indians make money on this tree, because it has so increased that the mountains are full of guavas. It has not been difficult for the plant to spread widely, because when the fruits are eaten by birds and other animals, the seeds do not disintegrate and, voided with the excreta, each seed produces a new tree. The Indian who enjoys going to the mountain secures a good load of the guavas and sells them in the neighboring towns of Manila. Those who live far from the capital take advantage of this fruit by maintaining themselves and their animals when it is in season, that is, in the months of August, September, October, and part of November. Through these guava thickets we reached the town of Calamba. Although small, since it has not more than 300 tax-payers, many of them scattered in the fields, the town is very neat. It has good gardens and not a few stately houses. The church is of bamboo, dirty, and unworthy of the mass that is said there. The minister is a native priest, who is bothered but very little by the slovenliness of his church.[2] There is likewise a good house of stone and tile, where dwells the administrator of the estate, which belongs to the King, who grants the lease to the highest bidder at a public auction.

The former owners of this land were the expelled fathers of the Society [of Jesus], who built a big dam on the Tanauan River,[3] which empties into the lake at the shore of this town. By means of this dam were irrigated that great plain and other vast rice lands which are now full of guavas. Since it passed into the hands of the administrators, the dam was allowed to deteriorate, and all these rice lands are now uncultivated and idle. On account of the nearness of the towns of Cabuyao, Santa Rosa, and Biñan, none cares to gamble on an uncertain crop when in these neighboring towns there are irrigation facilities and, hence, an always sure harvest. In addition

[2] Father Martinez de Zuñiga's adverse criticism, although probably deserved, may have been prejudiced. This author was a Spanish Augustinian, a member of one of the religious orders who, three decades earlier, had given up many parishes in the Philippines as a result of a bitter controversy with Archbishop Basilio Sancho de Santa Justa y Rufina on the question of canonical visitation. The vacancies thus created were filled by appointment of native secular priests, many of whom unfortunately had been poorly trained. They had been ordained too fast in order to meet the sudden lack of parish priests, which had become acute particularly since the expulsion of the Jesuits in 1768.—L. B. U.

[3] Part passing through Calamba is now known as the San Juan River.—L. B. U.

to these lands, Calamba has many places whereon may be planted wheat, corn, mungo, kidney beans, Lima beans, pepper, and all the kinds of fruits that are produced in the province of Batangas. It abounds in high-class wood and there are excellent pastures for live stock, of which there is a herd of cattle owned by the estate itself. It had been three or four years since the King sold all the Jesuit estates, which we call "temporal things." The Calamba estate was priced at 15,000 pesos and no buyer could be found that would offer this small sum for an estate that is provided with such conveniences and utility. It is true that one must invest a much larger amount for repair of the dam, but it is likewise true that in a few years enough will have been produced to compensate, and if one wishes to spend more, this estate is capable of becoming the richest of its kind in the Philippines. The King finally bought it for more than 40,000 pesos.

The town of Calamba is unhealthful and is too predisposed to tertian fever. I saw there many Spaniards suffering from this disease, which is less common elsewhere in the Philippines. The nearness of Mount Maquiling and the small extent of the land on the shore of the lake are doubtless the cause of this malady. The air does not flow freely and the material given off by decaying leaves and trees in the mountain enters the skin pores or attacks the muscles, producing therein a spasm, which is the beginning of tertian fevers. Or else, the miasma that issues from the marshes produces the sickness in the body, through a mechanism which the physicians would know how to explain better than I can. In order to correct this handicap, it is only necessary to transfer the townsite to the other side of the river and locate it on the same shore of the lake, whereby not only would it be farther away from the mountain but also it would be exposed to winds from the lake, which bring health to all towns on the lakeshore despite nearness to mountains.[4]

With nothing more to see in Calamba, we mounted horseback and shortly we reached the shore where we took a small boat for the town of Los Baños, which is about a league distant by the lake. The Indians call this site *Mainit*, which means "hot," on account of the hot springs occurring there. Before docking, we descried some big smoking mounds, which we found later to be some sort of ovens that had been built upon the hot water to catch the vapor. On top of

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[4] There has been no case of malaria in the town of Calamba in recent years, owing probably to pollution of streams where *Anopheles* larvae breed, as a result of increase in population.—L. B. U.

each of these was a flue for the passage of the vapor, which appeared like the smoke escaping from a pile of fresh twigs when it begins to burn. We disembarked near the convent and proceeded to scale the coast until we reached the level of the first story of this building, the entrance to which was flush with a flatland above. Toward the lake side it was markedly raised from the shore. This convent is hardly enough for a priest and the many patients that go there for the baths. For these pilgrims the Franciscans have erected a good church in the middle of the flatland behind the convent and they are constructing a new building for housing the priest and the privileged patients. There will be accommodation for all that may come to seek a cure in these waters. I do not know how the Franciscans can meet these additional expenses, let alone maintain the buildings they have at present, because in the town the tax-payers do not reach one hundred and there is no likelihood that this number will increase, for there is no land. Between the lake and the mountain, there is not a palm of land that can be cultivated. On the mountain side are some small level lands which yield sustenance to the natives, but the land area is too small to support a large population.

These priests of mercy have no other means of support than the alms of the faithful; but because these are few, there is hardly enough to keep the establishments that they have built. Among the many pieces of uncultivated and unappropriated land in the Philippines, one piece may be granted to the hospital to provide for the needs of the patients. In any other part of the world the most effective means are taken for subsidizing a hospital which is fraught with great benefits to humanity. It is only in the Philippines that the little it already has is taken away. Facing the convent is a small island in the middle of the lake. I do not know by what right the hospital originally claimed ownership of it and assigned an Indian there to raise poultry for the patients, giving the caretaker the privilege of cutting bamboo and other wild trees on the island. The powers that be in Manila deprived the hospital of this small income by converting the island into communal property and allowing everybody to make use of the island. The result has been that, without benefiting the other Indians much, considerable harm was caused the hospital.

This town is located on the side of Mount Maquiling. Its land is mountainous and incapable of producing rice and other fruits of the Islands, except in small quantities. From the mountain are obtained some lumber, honey, wax, several kinds of palms and roots,

like camote, gabi, yam, and others that the Indians eat. There is also white earth, similar to the Spanish plaster of Paris, which is used in Manila for whitewashing and painting. Enough fish is caught in the lake, although of poor quality, and these products together with some needlework that the women make are what support this miserable town. The climate is wholesome, because, being near the lake and exposed to almost all the winds, the mountain does not infect it, as it does Calamba, which is somewhat secluded. All over this mountain are found several wells of boiling water, but what constitutes the baths is a small stream that runs over a bed of hard rock, which, it is surmised, was dug by hand and which passes in front of the convent. As the water runs downward, exposed to the wind, it loses some of its heat, but not very much, because where it empties into the lake itself, the temperature is such that it scalds the hand. It is so hot at the head of the stream that an egg may be cooked there in four or five minutes, and a dog that had accidentally fallen in came out entirely peeled.

On this stream are three ovens distant one from another in such a way that a greater or lesser heat may be obtained, according to the need of those going through the vapor treatment. A small dressing room is attached to the oven. It is poorly arranged and it is very inconvenient to go stripped from there into the oven; but the hospital has not any fund to meet current expenses and make a rearrangement of these establishments. One who takes the vapor bath enters the oven, closes the door and keeps himself there with a great deal of effort for the time that the physician prescribes, which can not be very long, because the steam issuing from the water is very heavy and, even with the flue overhead, it does not dissipate easily. Much discomfort is caused by the oppressiveness and heat. In addition to these ovens there are other very curious baths. In one of them, mineral water enters after cooling somewhat in the air; in another, there is a bath of ordinary water and a well of hot water with a mechanical attachment that mixes with the bath the quantity desired to raise the temperature as required by the patient. Some drink this water and make use of the baths and vapors according to medical prescription or according to their whims, for which reason not as many cures are effected as might have been otherwise. Perhaps the physicians themselves have not the necessary knowledge to draw up a convenient schedule and prescribe the proper method of using these baths. The General [Ignacio María de Alava], after our return to Manila, sent two navy doctors to make an analysis of

these waters and they determined the kinds of diseases for which these are applicable. They said that they were exactly similar to the other mineral hot springs found in several places in Europe and that their application should be according to the rules laid down by authorities. We were told by the Franciscan priest that, from his own experience, as well as from that of his predecessors, these waters are harmful to persons of a fiery and hot disposition, but very helpful to the phlegmatic, and, therefore, very good results were obtained with the dropsical and all sufferers from water and pressure in their fibers. If this is the case, many will be benefited in these Islands, where there are so many victims from phlegmatic humors [probably meaning goiter].

The source of the heat of these waters and of the other wells and springs on this mountain assuredly is not some subterranean fire, but some mixtures which are continually decomposing. In the same way that quicklime boils when thrown into the water and is capable of heating a kettle, it is not difficult to think that there must be some mixture in this mountain that might possess identical or similar properties. We dug into a hard rock in front of the convent, one or two yards higher than lake level, and we made a hole half a yard deep. A little below the surface of the rock we found a spring of boiling water, and what was more amazing was that on the surface of the rock no heat was felt. I do not believe that this water gets heated in the mountain itself, because then in passing through the pores and conduits of soil and rocks, it would have cooled off. It would not be easy to develop within a volcano the heat that Maquiling gives out in various parts. Let us suppose that there are some concavities filled with air and some sulphurous minerals. As the air comes to rarefy and sulphur gets ignited, we would have a volcano like Taal, which throws out flames, lava, earth, and unignited sulphur, such as issued from Taal in other times. This premise, which none can deny, proves irrefutably the falsity of the contention of Mr. Buffon, a great man elsewhere.

It is believed in Manila that in the stream of boiling water fish live and get themselves established. Some travellers who heard this story in Manila broadcasted it in their travels as though it were a certainty, and philosophers have discussed the way by which fish may live in boiling water. Indeed, the modern philosophers annoy me with the way they hold on to their beliefs. Pledged to combat religion, they have denied all miracles, because they said that to believe one whereby God changes natural laws, it must be seen and felt. "I

would believe first," said one of these atheists, "that all Paris lies and wishes to cheat me, rather than that the dead should come to life." According to Bayle, Spinoza himself said that if he had witnessed the resurrection of Lazarus, he might right then and there have believed in the Catholic Religion, but that after so many generations, none should give credence to that resurrection. The same philosophers are disposed to believe and insist upon the truthfulness of travellers' tales, such as those about fish living in the hot water of the baths. I carefully examined that place and not only did I not find a single fish, but I was convinced that it is impossible for any living thing to exist there.

Photograph by Julian Banzon

Feminine art in pineapple-leaf fibers

INSECTS IN PHILIPPINE FOLKLORE [1]

LEOPOLDO B. UICHANCO
Of the Department of Entomology

WITH FOUR TEXT FIGURES

A fascinating branch of Philippine entomology that has hardly been explored is that which deals with the part of insects in superstitious beliefs. An attempt is made in the present paper to bring together such material along these lines as could be secured, largely from the Tagalog region, and especially from the province of Laguna, with which the writer is particularly conversant. Students and colleagues at the College of Agriculture and the School of Forestry and other friends elsewhere were, likewise, consulted for items from additional Philippine localities.

Fear of moths. The Pampangan term *cambubulag* for moths is expressive of a prevalent notion in many parts of the Archipelago that the scales and hairs of moths cause blindness. This belief doubtless arose from disagreeable random experience with poisonous species, such as members of the family Lymantriidae. The misdeeds of a few have given a bad name to the entire community of moths.

Omens. A black or somber-colored moth or butterfly is an evil omen. When it enters the house, it forebodes death, especially if at night the moth puts out the light in the oil lamp, which until quite recently was the only source of illumination in the country home. The light-colored moths, however, such as *Diatraea, Schoenobius, Topeutis,* and *Sesamia,* are good-luck signs.

Another messenger of death is the *dalúni* (Tagalog), which is the larva of certain species of fungus gnats. The dalúni are sometimes seen in damp places, where they form a long procession, hundreds of individuals marching together. The rural folks distinguish two kinds—the black-headed, whose entrance into the house is a forerunner of disaster, and the pale-headed, which does not bring death, but good fortune. Still another bearer of dismal tidings is an army of black day-foraging termites, *Hospitalitermes luzonensis* (Oshima), when this invades dwellings; an army of yellowish ants, on the other hand, presages wealth (gold). In Palawan, a fly stray-

[1] Experiment Station contribution No. 1193.

ing into the room at night bodes ill for the occupants. It is the belief in Pangasinan that to kill a dragonfly is to invite sickness. The music of the katydid announces death among the Bicols, at least in Albay province. A firefly entering the house is a notice that the owner's field is being destroyed by animals at the moment. The fact that the last belief is met with in such widely separated localities as the Tagalog province of Laguna and the Ilocano province of Abra, is probably an indication that it is a fairly general one among the lowlanders of Luzon island.

The singing cicada is distinguished from the voiceless, not as the male and the female, but as the vocal and the dumb. In Pampanga, it is considered bad luck to encounter a dumb cicada.

Drawn by A. Y. Coronel

Human-faced pupa of a lycaenid, Spalgis substrigata (Snellen). × 7

Wandering souls. Perhaps a relic of an ancient faith, antedating Magellan, is the current belief among Tagalogs, Pampangos, Ilocanos, Pangasinans, and certain other people in Luzon, that when a person goes to sleep, his soul temporarily quits the body and roams about freely. The sleeper, therefore, should not be roused brusquely, for then his soul may not find sufficient time to hasten back from its wanderings. As an extension of this belief, probably, the Bicols and, to some extent, the Ilocanos also, are averse to killing insects and other small animals at night. These creatures might momentarily harbor the souls of their sleeping children, and thereby these loved ones might meet their inglorious end.

Human-faced pupa. A species of lycaenid butterflies, *Spalgis substrigata* (Snellen), the caterpillars of which are predaceous on common mealybugs of ornamental plants, is sometimes unusually abundant. The pupae bear a curious resemblance to the human face, with eyes, nose, and mouth rather well marked. The late Dr. Leon Ma. Guerrero once informed the writer that, during the past Philippine revolution against Spain, numerous pupae of this kind were seen. The revolutionists heartened at the sign; it foretold defeat of the enemy. The pupae represented the impaled heads of Spaniards. In times of peace, however, an abundance of these pupae presages a coming war. Human-faced shapes in tamarind and other plant seeds are, likewise, given similar interpretations.

Old man of the termite hill. A common object of superstitious fear in fields and open places is the termite mound. It is believed to be the home of an impish old man, known as *nuno* (Tagalog and Pampango for grandsire or old man) or *apo* (Ilocano, Pangasinan). The nuno (apo) is supposed to be as hideous as he is mischievous and to be small enough to fit into his little dwelling. Because he is normally invisible, one constantly runs the risk of stepping on his toes or otherwise incurring his displeasure, which may mean illness or death to the unwary offender. The hapless trespasser is lucky if he escapes with only a few minor dark patches on his skin, which are presumably marks left there by the bruising pinch of the old culprit. A kind of eruptive skin disease, common in children, is attributed to his malicious prank. Occasionally, a case of illness is treated in Batangas province by removing a large cubical chunk off the top of the nearest termite mound and exploding, Chinese-fashion, a bunch of firecrackers in the resulting cavity. The explosion kills the nuno; the ailment for which he is responsible miraculously stops its course. Care is taken, however, not to touch a termite mound if this is located under the house, because such a misstep would mean death to one of the occupants. In the Bicol provinces, on the other hand, a mound under dwellings will bring death if it is not removed.

A customary etiquette in the wild is to address the unseen prowler now and then, asking him to let one pass or to allow one to pick some guavas or whatever it is one may intend to do. With all this fear of the nuno, however, the country folks do not hesitate to gather the prized edible mushroom called *mamunsó* (from *punsó*, Tagalog

and Pampango for termite mound), *Collybia albuminosa* (Berk.) Petch, which grows only on this bogey-man's home. This species is not associated with the nuno in popular fancy, but, like other mushrooms, it is believed to be a child of thunder. The clayey wall of the termite mound is frequently used as a vehicle for brine in preparing salted duck's eggs.

In Siam, according to Siamese students at this College, the mysterious dweller of the termite hill, whom they call *phra poom chow tee,* is supposed to be a handsome being; he is one of the gods. But he is, likewise, reputedly of an ugly disposition. The Philippine

Photographic Division, C. A.

Mamunso, Collybia albuminosa (Berk.) Petch—a "child of thunder"

nuno may have been originally personable, like his Siamese counterpart, and doubtless he had been a deity at one time, until a remodelled taste assigned him a misshapen hue and the Christian religion bereft him of divinity.

Household remedies. A lotion consisting of houseflies mashed in coconut oil, when applied on the scalp, is believed to grow hair on bald heads. On the clean-shaven scalp of children, this remedy is supposed to induce a more luxuriant growth. The silken house of the common large bagworm, *Oiketicus tertius* Templ., is said to be

a preventive of abdominal gas in infants when the cocoon is held against the navel by means of a string girdle. The mud wall from the nest of the wasp *Odynerus hemorrhoidalis* var. *ater* (De Saussure) is reduced to a thick paste in vinegar and applied as a poultice on mumps.

Fireflies. Certain trees, such as the camachile (*Pithecolobium dulce* [Roxb.] Benth.), datiles (*Muntingia calabura* Linn.), madre de cacao (*Gliricidia sepium* [Jacq.] Steud.), and the rain tree (*Samanea saman* [Jacq.] Merr.), are particularly attractive to fireflies. On a clear night some of these trees glitter with their imposing galaxies of phosphorescent beetles. The ground and the surrounding landscape are bathed in a soft, eerie brightness. People ordinarily give such places a wide berth for fear of malignant beings that lie in ambush in the spooky shadows. The bold, however, may find occasion there for a test of strength and valor. Around midnight he goes unarmed to the firefly-laden tree and bites with his teeth a piece of bark from the trunk. Forthwith an ogre appears and wrestles with him. If he overpowers the ghostly assailant, our brave hero's prize is the piece of bark. It is an *anting-anting* (charm), possession of which renders one invulnerable.

Pest control. A number of superstitious practices naturally have to do with farming. A friend from Batangas described to the writer a method of keeping armyworms off rice seedlings. He had learned it years before from an old farm hand in his native province. Take five short pieces of a kind of bamboo called *anos, Schizostachyum lima* (Blanco) Merr. Set one into each of the four corners of the field, in a counterclockwise order, and the fifth into the middle. Insert into the internode of each piece a sheet of paper on which a magic formula is written. The phrases used—unintelligible to us humdrum folks—are Latin or Latin-sounding, except *hwag,* which is Tagalog for "don't" or "let not." Inscription for the first corner piece: *Hwag impasim.* For the second: *Hwag iniripsum.* For the third: *Hwag idormeam.* For the fourth: *Hwag requisiam.* For the middle piece: *Corpus Christi, sanctificarme, salvame, salvame, salvame.*

The rice armyworm, *Spodoptera mauritia* Boisduval, be it noted, is a peculiarly docile subject for treatment by hocus-pocus. As a rule, only the full-grown larval instars molest the rice and then only when the seedlings are not older than about a month, while the leaves are still tender. A swarm of caterpillars usually breaks out,

eats its fill, and then vanishes with dramatic abruptness. Advance of the rainy season and increase of parasitic enemies,[2] together with pupation in the ground of the last larval instar, cause a spectacular wholesale disappearance. Then it is that the charm does its wonderful work, the pest gets "under control," the crop is saved!

Likewise, locusts are said to keep off a field on which stands a bamboo cross. Inside the internode is a piece of paper with the closing prayer in Spanish of the Trisagion.

Here is a formula to enable a person to pick up a nest of the fierce paper wasps, *Ropalidia* spp., without getting stung: *Hom-hom, illo hukóm, ego sum empactum, oracion sa putakte at sa taong may bune.* The performer is supposed to recite these words with meticulous precision and unshaken faith; otherwise, they lose their power. The writer can attest to a boyhood experience with this method, although he can not say that meticulous precision and unshaken faith were of much help in saving him from the savage sting of infuriated wasps.

Outside of incantations, there is, or rather was, that gruesome practice of protecting the rice plants from insect pests by burying in the levees, near the head of irrigation water in the field, human bones that had been furtively exhumed in the cemetery. Utmost secrecy has to be observed in these operations, not so much to keep out of trouble with public-health officials, as to prevent the insects from getting wise to the trick, lest all the work should come to naught. Instead of human bones, the tusk of *baboy dagat* (literally, sea hog, Tagalog), or dugong, may be used. Rice bugs, *Leptocorisa acuta* Thunberg, are believed to be attracted to baits consisting of an aquatic weed, *digman, Hydrilla verticillata* (Roxb.) Royle, which is done up in cloth bags and hung on poles.

Another way of outwitting the insects is to gather the seeds for planting and deposit these in the yard at night, under cover of darkness. A practice among the Bicols, reminiscent of the ostrich among Europeans, is to close the eyes while planting the first three rows of corn in the field or the first three handfuls of rice in the seedbed, so that the pests may not see what the planter is doing. Ac-

[2] The natural enemies of *Spodoptera mauritia* so far known in the Philippines, according to specimens bred in our insectary and determined at the United States National Museum, are:

On eggs: *Telenomus* sp. (near *nawaii* Ashmead).

On larva: *Charops longiventris* Ashmead, (?) *Inareolata* sp., *Microbracon* sp. nov. [Gahan], *Microplitis manilae* Ashmead, *Chelonus* sp., *Brachymeria* sp., *Apanteles ruficrus* (Hal.), *Apanteles* sp. nov. (near *cheesemani* Wilk.) [Muesebeck], and two species of tachinids.

cording to a belief among Tagalogs, seeds of any crop, if carried in the pocket, instead of in the hand or in a separate container, grow into plants which are inviting to insects. Cucurbits are said to be less prone to damage by the leaf beetle, *Ceratia similis* (Olivier), when the seeds are planted on an empty, rather than a full, stomach. One must not enter a cucurbit patch while the leaves are wet with dew.

Other agricultural superstitions. There are, of course, scores of other interesting superstitions connected with agriculture in its various phases. These items are purposely excluded from the present paper, inasmuch as they have no bearing on insects. One particular example, however, deserves a passing record, because among the Philippine popular beliefs about insects, there apparently is not an equally striking illustration of a surviving form of primeval religious ritual, where man is supposed to initiate the plants, by personal example, into the secret of reproduction. The *makapunó* (from the Tagalog *punó*, full) is a highly prized kind of coconut which is produced only in very few trees in a grove. Instead of containing the usual water in a large central cavity, the shell is packed with a solid, custard-like mass, which is in demand for making sweets. To insure production of *makapunó*, so they say in Laguna, the planter should first gorge himself with rice gruel (*nilúgaw*). In the act of planting, he should bare his cod and let it touch the ground.

Common-sense beliefs on flies. Not all superstitious beliefs are meaningless vagaries. Quite a few are obviously logical generalizations from observed phenomena, although at times these may be tinctured with fantasy. In the mango season there are many flies, according to a Tagalog belief. Flies are plentiful following a long dry spell; so are the mangoes, which can not stand rain when in flower. Flies bite in August, because, it is claimed, they are about to die. The common housefly, which, of course, does not bite, is confused in this case with the stable fly, *Stomoxys calcitrans* Linnaeus, prevalent in August. Both the housefly and the stable fly become quite scarce after August, at the height of the typhoon season, owing to the combined effect of disease and elimination by the rains of suitable breeding media.

Hot and cold. Certain persons, usually women, are said to be "malamig añg kamay" (with cool hands). When they salt fish or jerked meat, the product does not spoil. They, of course, have the knack of making proper incisions into the flesh, where salt permeates all the tissues rapidly and thoroughly. This precaution is overlooked

by those who are "mainit añg kamay" (with warm or hot hands), and the result is that their salted meat comes to life with maggots. Among Pampangans, such tyros are known as "mabuluc" (malodorous), the belief there being that the meat or fish spoils because the operator does not wash the hands after coming from the toilet. Persons who have the uncanny ability to make plant cuttings grow or to fatten a baby or domestic animal are also termed "cool-handed"; otherwise, they are "hot-handed." For that matter, the Tagalog "mainit," the Pampango "mapali," or the Ilocano "napudot" often bear connotations quite different from the common English equivalent, "warm" or "hot". Locust, *Locusta migratoria manilensis* (Meyen), is said in these Philippine languages to be a "hot" food. Diseases such as dysentery are believed to be due to heat and to be caused by eating too much cooked locust. Locust years in the Philippines are, of course, usually dry years,[3] when epidemic human diseases are also quite prevalent. Perhaps this grim association with pestilence has led to the locusts being popularly regarded as creatures on which a curse has fallen. Even their excreta are taken to be rice grains that have shrivelled up from the malignity of this curse.

Weather forecasting. Some insects, birds, and other animals are regarded as weather prophets. Unusual flight activity of cockroaches, when they restlessly soar about the room, and the swarming of midges, winged termites, and ants are taken as harbingers of rain. Colonies of the fire ant, *Solenopsis geminata* Fabricius subsp. *rufa* Jerdon, excitedly gathering about the opening of their nest, and earthworms crawling on the surface of the ground, instead of remaining in their burrows, even on a fine day, foretell heavy squalls. At least in the case of the common mound-building termite, *Macrotermes gilvus* (Hagen), controlled findings in our laboratory have shown some relationship of swarming flight with an increase in atmospheric humidity.[4] When termites fly to the light, the swarm, it is claimed, will grow larger if some one makes a remark about it.

The Pangasinans interpret the entry of a firefly into the house differently from the Tagalogs of Laguna and the Ilocanos of Abra. They believe, perhaps rightly, that this phenomenon indicates rain. The probable explanation of this belief is that in threatening weather the fireflies do not ordinarily congregate on trees but they fly about

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[3] UICHANCO, LEOPOLDO B. 1936. Secular trends of locust outbreaks in the Philippines and their apparent relation with sunspot cycles. The Philippine Agriculturist 25: 321–356. *1 map; 12 charts.*

[4] PANGGA, G. A. 1936. A biological study on some common Philippine termites. The Philippine Agriculturist 25: 233–265. *16 fig.*

aimlessly as isolated individuals. In this way, a firefly finds its way into the room.

A coming rain is said to be felt in the manner by which owl midges, *Phlebotomus nicnic* Banks and other species, bite. Then, these very annoying little pests are particularly aggressive and vicious in their attack on people.

That spiders do not repair their webs when rain is coming is quite well known in rural districts. Because knowledge of this phenomenon is common to many countries of the world, there is an even chance that it might be an imported idea in the Philippines.

Photograph by Julian Banzon

A common mantid, Hierodula patellifera Serville. The mantid is "mother of snakes"; its egg-masses, "dross from shooting stars"

When the house swallow, called *layang-layang* (*Hirundo javanica* Sparrm.), takes to wings, and large numbers circle about a place for sometime, people say, it is about to rain. Of course, the food of this bird consists of insects, the swarming activity of some forms of which may again be correlated with certain atmospheric conditions.

Praying mantis. The belief that the praying mantis is the "mother of snakes" is based on good observation, although the interpretation is erroneous. Mantids in the Philippines, as elsewhere in

the East Indian Archipelago, are frequently parasitized by a gordian worm. This nematode is dark brown and is of a fairly large size. When the abdomen of the mantid is accidentally hurt, the parasitic worm (baby snake!) wiggles out. The egg-masses of these insects are not recognized as such, but are believed to be dross from shooting stars. In Pangasinan, the twigs bearing them are gathered and used as baits in fish-traps.

Origin of locust outbreaks. Miguel de Loarca, a sixteenth century Spanish chronicler of the Philippines, records the following ancient Visayan legend:[5] "The deity Laon is said to live in a volcano which is on the island of Negros and which spits fire. The volcano lies about five leagues from the village of Arevalo. People invoke this Laon for their crops. When she will not grant these, she sends forth locusts which overwhelm and eat the crops. This Laon is a woman." Laon has since passed away, when people no longer believe in her. But the idea persists to this day that locusts originate in the mountains.

After the pagan goddess Laon had gone, the blame for locust outbreaks, strangely enough, fell next on the Archbishop. A common belief in southern and central Luzon is that locusts invade a place following a pastoral visitation by the Archbishop. How this belief came about may only be surmised. During the Spanish régime and for some time after American occupation (1595-1910), the Roman Catholic ecclesiastical government in the Philippines centered in the Archbishop of Manila. Prior to these dates, from 1578 to 1595, Manila had been the only diocese in the entire country with a resident bishop. Because of difficulty in communication, the Archbishop could inspect a distant parish and administer confirmation there only once in a good number of years. His coming was always a great social, as well as religious, event. He was received with bands of music amidst the frenzied ringing of church bells and exploding of rockets. He was greeted along the way, from the village gate to the church, by colored festoons, flags, and gaily decorated bamboo arches. The entire populace turned out in their best holiday fineries and flanked both sides of the road, where the faithful fell to their knees to receive his benediction as the Archbishop passed along in his carriage. These infrequent calls, which were long remembered by the inhabitants and used as dates of reference for other local events, must have been followed in some places by the appearance of swarms of

[5] LOARCA, MIGUEL DE. 1582. Relacion de las Yslas Filipinas. Blair and Robertson 5: 34–187.

locusts during these insects' periodic outbreak cycles. That impressive sequence, together with fancied resemblance between salient morphological parts of the locust and clerical habiliment, could conceivably have conjured up the unique connection in the credulous minds of simple country folk. From locusts, the association grew with the years into other calamities. In Pampanga, even floods, earthquakes, and similar spectacular mishaps are believed to follow in the wake of the Archbishop.

Bamboo-cutting. Tradition has decreed that there be only three weeks during the year to cut bamboo. This open season begins, in and around Laguna, with the first *misa de gallo*, on December 16,

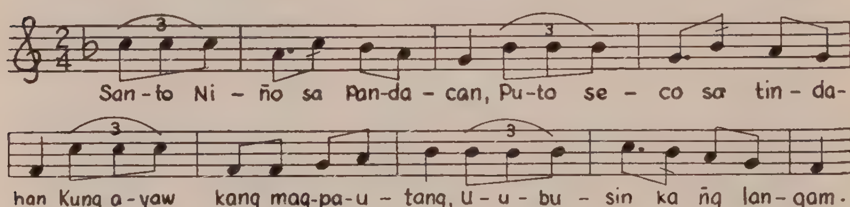
Photographic Division, C. A.

"Off-season" bamboo

and ends on the Epiphany, January 6. When cut outside these dates, bamboo stems are supposed to be subject to attack by powderpost beetle, *Dinoderus minutus* Fabricius, which is the worst enemy of bamboo construction in the Philippines. In our most important structural bamboo, *Bambusa spinosa* Roxb., the mature stems of at least a year's growth are less susceptible to infestation than the younger ones. Because bamboo harvesting around Laguna often means gathering all the bigger-sized stems on the clump, the limited season set by custom unwittingly allows the necessary year's growth between cuttings. In western Pampanga, where the manufacture of *sawali* (woven bamboo wall-board) is an

important industry, the *búho, Schizostachyum lumampao* (Blanco) Merrill, is a more valuable bamboo than *Bambusa spinosa.* The former species is quite resistant to *Dinoderus minutus.* Hence, in that locality bamboo-cutting time is more generously distributed; it falls in the months of which the Spanish names contain no *o*—April, September, and December.

Influence of Christianity. The origin of many superstitious beliefs is lost in antiquity. Since its introduction into the Philippines, Christianity has, to be sure, put a renovating touch on a number of time-worn usages. Unfortunately, the result has not always proved a happy one, because the changes have not been the work of friendly and understanding hands. Likewise, the Christian religion has become an unintended foster parent to new superstitious beliefs, as the traditional cutting season of bamboo, the exorcisms against insects, and the naïve association of the locust with the Archbishop very plainly indicate. We have, moreover, the following Tagalog folk song:[6]



Santo Niño sa Pandacan,	Holy Child at Pandacan,
Puto seco sa tindahan—	Puto seco[7] in the shop—
Kung ayaw kang magpautang,	If you sell not on credit
Uubusin ka ñg langam.	The ants will eat you up.

[6] Musical notation by Dr. Dionisio I. Aquino, of the Department of Soils. At least two other versions exist which are sung to the same tune, thus:

a. Sitsiritsit alibangbang,	*b.* Santa Clarang finong fino,
Salaginto at salagubang;	Nakabaksa't nakapolvo,
Ang babai sa lansañgan	Ang manliligaw dito
Kung gumiri'y parang tandang.	Magdodote ñg sanglibo.
Sitsiritsit alibangbang,	Very genteel Santa Clara,
Golden beetle and cockchafer;	With her neckerchief and powder,
The women on the highway,	Whosoever seeks to win her
When they strut, are like a rooster.	Gives a thousand-peso dower.

[7] A kind of sweet, dry biscuit, prepared without shortening from rice flour.

Superstitious beliefs and history. Removed from their original context, not a few superstitious beliefs lose their logical place in an orderly universe of thought and, hence, they often reappear at the present time in unbelievably absurd forms. It is quite evident, however, that a good proportion of these beliefs demonstrably represent masquerading fragments of common-sense practices. They have been the product of cumulative human experience in coping with local conditions. These are, therefore, worthy of at least a sympathetic consideration, especially if viewed alongside Saint Augustine's dictum (Quaest. Evang. ii, 40): "Nulla falsa doctrina est, quae non aliquid veri permisceat." What is more, traditional lore is about the last of our receding cultural links with the prehistoric past. Written history in the Philippines dates only to the beginning of the Spanish régime, thanks in a large measure to the assiduous labors of Spanish religious. The reason is not that ancient Filipinos left no writings. In their holy zeal to preserve the Philippines exclusively for Roman Catholicism, early Spanish missionaries turned their then unlimited powers to purging the Philippines of things they deemed off-color with established religious doctrine. We learn, for instance, from Father Pedro Chirino,[8] at the turn of the seventeenth century, that in one town alone in what is now the province of Batangas, not less than three hundred manuscripts in ancient Tagalog alphabet were destroyed. "Then began a new era for the Filipinos," bewails Rizal.[9] "They gradually lost their ancient traditions, their recollections—they forgot their writings, their songs, their poetry, their laws, in order to learn by heart other doctrines, which they did not understand, other ethics, other tastes, different from those inspired in their race by their climate and their way of thinking. . . . Thus years and centuries rolled on. Religious shows, rites that caught the eye, songs, lights, images arrayed with gold, worship in a strange language, legends, miracles and sermons hypnotized the already naturally superstitious spirit of the country, but did not succeed in destroying it altogether, in spite of the whole system afterwards developed and operated with unyielding tenacity."

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[8] CHIRINO, PEDRO. 1604. Relacion de las Islas Filipinas. Rome. Blair and Robertson 12: 13.

[9] RIZAL, JOSÉ. 1889. Filipinas dentro de cien años. La Solidaridad, Madrid, September, 1889. Translation by Charles Derbyshire in Craig, Austin. 1927. Rizal's Life and Minor Writings, p. 222–263. Manila: Philippine Education Co., Inc.

American influence on Philippine folklore. During an engagement with hostile Filipino troops in February, 1899, the American army, as a military necessity, set fire to the magnificent three-century-old Guadalupe monastery,[10] burning with it the priceless collection of books, manuscripts, and relics of the Augustinian Order. Scarcely could these strange invaders from the Western Hemisphere have known then that they were wreaking an ironic vengeance, by turning the same agent of destruction against a kindred civilization which in its time had made effective use of fire in the Philippines. In the unsettled days following the capture of a native village, irresponsible vandals among the American soldiers plundered many an evacuated Filipino home of its valuables, not excepting sacred objects—carved ivory images of saints and their expensive gold ornaments. Aside from such unfortunate incidents of war, however, the Americans did not deliberately go about consigning ancient Filipino documents to the flames. They garroted no disgruntled Fathers Burgos, Gomez, and Zamora to set an example of abject submission. They shot no Rizal at sunrise for expressing honest disagreement with their belief or politics. They sowed no haunting fear of eternal damnation by burying without coffin the corpses of unrepentant heretics outside the gates of consecrated ground. But, for good or ill, the four brief decades of American occupation did incomparably more to occidentalize the far-flung corners of the Philippines and to kill superstitious beliefs in a thoroughgoing manner than the four long centuries of Spanish rule. From being ushered into the world amidst the reassuring odor of American antiseptics, little Juan de la Cruz gets drawn as a matter of course into a vast public-school system that bears the unmistakable stamp of Uncle Sam's inspiration. He learns, among other things, to chuckle over Yankee comic strips and to

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[10] A historical marker has since been placed on the ruins. It bears the following inscription, prepared by Rev. Miguel Selga, S.J., director of the Weather Bureau:

CHURCH AND MONASTERY OF GUADALUPE

The foundations of this church and monastery of the Augustinian Order were laid in 1601 and construction work was finished in 1629. Nuestra Señora de Guadalupe was chosen titular Patroness in 1603. After the Chinese uprising of 1639 this sanctuary served as a seat of devotion for the Chinese. The buildings withstood the earthquakes of 1645, 1658, 1754, and 1863; the masonry roof of the church collapsed in the earthquakes of 1880 and the structure was rebuilt in 1882 by Rev. José Corujedo, O.S.A. Site of an orphan asylum and trade school administered by the Augstinian Order for the benefit of the children of the victims of the cholera of 1882. Both church and monastery were gutted by fire in February, 1899, during the early skirmishes between Americans and Filipinos.

thrill at Hollywood melodrama. In his adolescence, he coaches his love notes in delicate Anglo-Saxon phrases and pours the beauty of his inner soul over the perfumed warmth of American cosmetics. The momentum of Americanization has taken a tempo that knows no stopping in the Philippines. If we make no determined effort to retrieve now the few surviving shreds of our native lore, these, too, will soon be lost where we shall never find them again. There is doubtless wisdom in Hendrik van Loon's assertion, "that the future belongs to the living and that the dead ought to mind their own business." But there are still those of us who are old-fashioned enough to believe, too, that we can only live the present more fully and face the future with greater confidence when we project current cultural development against the tried background of the past.

OBSERVATIONS ON THE SWINE FOUND IN NUEVA VIZCAYA AND THE MOUNTAIN PROVINCE [1]

MARIANO MONDOÑEDO
Of the Department of Animal Husbandry

From time to time information has come to the College of Agriculture from students and friends of the College that some good types of native pigs may be found in certain regions of the Philippines. As the College of Agriculture is engaged in the task of developing a type and breed of swine suited for raising under a well-ordered system of farming, it is advisable to ascertain whether these reputed types or breeds of superior pigs really exist.

Among the places frequently mentioned as the home of excellent hogs in the Mountain Province is the subprovince of Ifugao, particularly the vicinity of Cababuyan, municipality of Banaue. Prof. H. Otley Beyer, well-known in the Philippines for his anthropological studies on the peoples inhabiting the Mountain Province, is one source of this information. The writer, therefore, undertook the trip to this region of the Philippines from December 18 to 29, 1936, with the object of inquiring into the matter, and to secure, if possible, good specimens of the animals. The trip was made by way of Bayombong, Nueva Vizcaya, from where the writer proceeded to Kiangan and then to Banaue. The investigation was extended to Bontoc. The places visited and gone over in detail were Bayombong and the adjoining barrios; Kiangan, the villages of Palao, Imapugan, Haliap, Duit, Bangaoan; Banaue, particularly the barrios of Cababuyan, Piwong and the outlying villages; and Bontoc, Sabangan, and Baguio. During the course of the trip short stops were made in a number of small villages for purposes of observation. The trips to the interior of Palao, Imapugan, Haliap, Duit, Bangaoan, and Cababuyan were made on foot and on horseback over trails and terraces along steep mountain sides. Travelling through these places in rainy weather could be undertaken only in the day time and with a guide, as the trips were difficult and attended with danger.

[1] General contribution No. 571. Received for publication on August 26, 1937.

THE HOGS IN THE MOUNTAIN PROVINCE

While in Ifugao the writer chanced to meet Mr. Juan Candelario, whom Professor Beyer mentioned years ago as the man who owned a herd of large hogs. This man, an Ilocano, now about 70 years old and still vigorous for his age, came to Ifugao in 1906, after retiring as a sergeant from the U. S. army. He settled in Cababuyan, and having married a wealthy Ifugao woman, started to raise all kinds of pets, fowls, and small as well as large live stock, including pigs. Captain Bulan related that very early during the American occupation, American hogs, presumably Berkshires, were brought to Banaue. These were crossed with native pigs, and the hogs which formed the foundation stock of Mr. Juan Candelario's pigs must have had an infusion of the Berkshire blood. These hogs, according to him, attained very large sizes, similar to those called Johnny now found in Batangas.[2] The business progressed uninterruptedly until a severe outbreak of disease among hogs occurred, and before the year 1927, his stock of large pigs was wiped out entirely. At the time of this visit the pigs seen in Cababuyan were small, ill-conformed animals, not different in general characteristics from the general run of native pigs seen in Nueva Vizcaya, Bontoc, Benguet, and La Union.

THE NATIVE PIGS IN NUEVA VIZCAYA, MOUNTAIN PROVINCE, AND LA UNION

The native pigs seen in Nueva Vizcaya, Mountain Province, and La Union, and known in these places as Ilocano pigs, are generally black with white spots or splashes. They are small, with long, straight, narrow heads, very short bodies, fairly straight backs, pendant bellies, short drooping rumps, short straight hair, and long but strong legs. When mature, these pigs average about 50 kilograms in weight. In the Mountain Province, these Ilocano pigs have replaced almost entirely the old mountain type of swine that existed before the advent of good roads connecting the upland regions with the lowland. All the people interviewed by the writer verified the statement that when the upland regions were isolated, owing to the lack of good roads from the lower regions, no cases of hog cholera or any other serious infectious diseases affecting hogs occurred. They recall that at that time the mountain type of hogs was distinctly large, although in markings it was not unlike the Ilocano hogs. But since 1927,

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[2] In Batangas, these crossbred pigs are called *Diani*, presumably because one of the early boars answered to the name Johnny.

the small Ilocano hogs became numerous by the influx of this type from the lowland provinces on all sides. The cañao and the liking of the mountain peoples for pork made it necessary to import hogs for lack of home-raised animals.

All the pigs seen by the writer, whether it be in the markets, buses or trucks, on the road sides or elsewhere, were small, thin, rough-looking animals. The information was gathered that the Ifugaos prefer lean pigs to fat ones since the former taste more like wild pigs and are better suited for cañao. The Ifugaos are willing to pay better prices for lean pigs; but this kind of pigs preferred by the Ifugaos has little or no market value in the lowland markets.

The numbers of the different kinds of live stock in the subprovince of Ifugao for the fiscal year 1935 are given in the following table:

	POPULATION	NO. OF HORSES	NO. OF CARABAOS	NO. OF CATTLE	NO. OF SWINE	NO. OF SHEEP	NO. OF GOATS
Banawe ..	18,273	20	100	50	4,000	0	200
Burnay ..	14,500	4	225	35	2,500	0	200
Hunduan .	11,002	172	463	879	1,787	0	15
Kiangan ..	19,380	60	612	1,655	878	160	120
Mayoyao ..	17,813	53	150	970	311	0	7
Total ...	80,968	309	1,550	3,589	9,476	160	542

(Courtesy of Governor Pauid, subprovince of Ifugao)

It will be noted from the foregoing table that the swine outnumber all the other kinds of live stock. It was explained to the writer that the Ifugaos do not generally eat the meat of goats and carabao; and the Ifugaos of Mayoyao rule beef entirely out of their menu. The pigs raised in Ifugao are not generally taken to the markets. They are used for home consumption or for cañao purposes; hence, the pigs that are found in the markets have to be brought from the lowland provinces.

At Baguio, the writer visited the slaughterhouse. He was informed that practically all the pigs slaughtered in Baguio come from the adjacent lowland provinces. The record from January to December, 1936, showed that the average number of hogs slaughtered in Baguio is 50 every day, giving 1,570 kilograms of pork, or an average of 31.4 kilograms of pork per pig.

THE BERKJALA PIGS IN BONFAL, NUEVA VIZCAYA

One of the most pleasant surprises which the writer experienced during the trip was afforded by the existence of a fairly large herd

of Berkjala pigs found in the barrio of Bonfal, Nueva Vizcaya. In this trip the writer was accompanied by Messrs. D. D. Clemente and C. Gallardo, both graduates of the College of Agriculture. Coming close to a farm owned by Mr. Dadufalsa, the writer sighted a large sow whose type and conformation looked familiar. Instantly, the writer exclaimed: "Am I not seeing a Berkjala sow?" It was genuine!

Years ago, Mr. Tomas Dadufalsa, a graduate of the College of Agriculture and for a time on the teaching staff of the Nueva Vizcaya Agricultural School, purchased Berkjala pigs from the College of Agriculture. A brother of his secured some of the progeny of these pigs and kept them pure. At the time of this visit there were over thirty heads of Berkjala pigs in the herd. The boar used for breeding was large, weighing not less than 200 kilograms. It had a long and strong back and presented excellent features of the breed. The herd was confined in an enclosure of about 600 square meters, not allowed free range but given grains and green soilage of all sorts. A thrifty and intelligent woman from Batangas took care of the management of the herd, and from her the information was obtained that the demand for this breed of pigs in the locality was great. Pigs sell at from fifteen to twenty-five pesos at four months of age and the supply is insufficient to meet the demand.

In conclusion, the writer wishes to state that large types of pigs were not found in any part of the Mountain Province visited. In Nueva Vizcaya large-sized hogs which have descended directly from the Berkjala breed of the College of Agriculture were found.

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to the officers of the Philippine army, provincial and municipal officials, and teachers of schools who assisted him in various ways, thus making the trip both pleasant and safe.

FLUCTUATION OF BODY TEMPERATURE IN THE INDIAN NELLORE BREED OF CATTLE[1]

MIGUEL MANRESA AND FRANCISCO GOMEZ
Of the Department of Animal Husbandry

It is the prevailing belief even among biologists that in homoiothermic animals such as mammals and birds, in the absence of infection, the body temperature remains constant, in spite of variations in the surrounding medium. Fronda (1925), working with chickens in Cornell University, found that the temperature of the room did not have any apparent effect upon the curves of the body temperature of chickens which he studied.[2] In the course of our studies on hematology of the different breeds of cattle in the College of Agriculture, data pertaining to body temperature of the Nellore breed of Indian cattle have accumulated. Determinations were made at four-hour intervals during a period of seven consecutive days. These data are here presented in their present fragmentary form, in view of the fact that they are wanting in veterinary literature.

In table 1 the means of body temperatures observed at different hours of the day are given, together with their standard deviations and coefficients of variation. These temperatures were taken from April 2 to 8, 1936, inclusive.

It may be noted from the table that the temperature of the body of Indian Nellore cattle is lowest at 6:00 a. m. and highest at 6:00 p. m. The diurnal temperature was 38.70 $\pm$ 0.015°C. The nocturnal temperature was 38.56 $\pm$ 0.013°C, and the average temperature for the day was 38.66 $\pm$ 0.022°C.

The coefficients of variation show that the fluctuations at four-hourly intervals varied within less than one per cent and, therefore, were very slight. However, when these variations were treated statistically they were found to show rather outstanding differences. Thus, the body temperatures at 2:00 a. m. were significantly lower than those at 10:00 a. m., 2:00 p. m., 6:00 p. m., and 10:00 p. m.

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[1] Experiment Station contribution No. 1194. Received for publication July 16, 1937. Read at the Fourth Philippine Science convention on February 23, 1937.

[2] FRONDA, F. M. 1925. Some observations on the body temperature of poultry. The Cornell Veterinarian. January, 1925.

The temperatures at 6:00 a. m. were significantly lower than those at 10:00 a. m., 2:00 p. m., 6:00 p. m., and 10:00 p. m. The temperatures at 10:00 a. m. were significantly lower than those at 2:00 p. m. and 6:00 p. m.; and those at 2:00 p. m. and 6:00 p. m. were significantly higher than the temperature at 10:00 p. m.

It may also be noted that the temperatures at 2:00 a. m. were not significantly lower than those at 6:00 a. m. Those at 10:00 a. m. were not significantly lower than the 10:00 p. m. record; and those at 2:00 p. m. were not significantly lower than the 6:00 p. m. temperatures. The average of the combined temperatures at 2:00 and 6:00 a. m. were significantly lower than the temperature either at 10:00 a. m. or 10:00 p. m. The temperature at 10:00 a. m. or 10:00 p. m. was significantly lower than the average of the combined temperatures at 2:00 and 6:00 o'clock, p. m. The difference of the diurnal temperature of 0.137 ± 0.020°C from the nocturnal temperature was 6.7 times its probable error, thus showing that in the Indian Nellore cattle the temperature during the day is significantly higher than the temperature at night. The foregoing relationships are readily discernible by reference to table 2.

Howell [3] reports some results of calorimeter experiments upon fasting guinea pigs in which it was claimed that, provided the atmospheric temperature was within 0°C and 33°C, the body temperature of fasting guinea pigs remained practically constant, but that the average oxidation within the body of these animals was twice greater than the amount under 33°C, at which temperature, according to Howell, the metabolism of mammals is at its maximum. At a much higher outside temperature, as for example, from 34.9 to 40.00°C, the heat-regulating mechanism breaks down. The loss of body heat is prevented to such an extent by the outside high temperature that the body temperature rises in spite of the diminution in heat production. Heat-stroke resulting from the rise in temperature of the body was explained as being due directly to prolonged exposure to excessively high outside temperature.

A direct verification of this finding has been afforded by the results obtained from our studies in which correlations were made between the atmospheric temperature and the body temperature at precisely the same hours of the day. The correlations proved to be positive and significantly high. According to Howell (1927), in

[3] HOWELL, WILLIAM H. 1927. A text-book of physiology. Tenth edition. 1080 pp. + 298 illustrations. Philadelphia and London: W. B. Saunders Company.

warm-blooded animals variations of outside temperature within ordinary limits do not affect the body temperature. Just what these limits are have been determined by neither Howell nor any other worker. In veterinary literature the subject is entirely unexplored.

The importance of this problem in its bearing on the introduction of animals of temperate climate origin into the tropics is not generally appreciated. It would seem to be of great value, therefore, to study the problem of acclimatization of the various breeds of live stock in the light of adaptability of body temperature to varying degrees of atmospheric temperature limits.

TABLE 1

Body temperatures of Indian Nellore cattle at different hours of the day

TIME OF DAY	MEAN	STANDARD DEVIATION	COEFFICIENTS OF VARIATION
	°C.	°C.	*per cent*
2:00 a.m.	38.49 ± 0.026	0.26 ± 0.018	0.68 ± 0.033
6:00 a.m.	38.46 ± 0.020	0.21 ± 0.021	0.54 ± 0.038
10:00 a.m.	38.61 ± 0.026	0.29 ± 0.026	0.75 ± 0.049
2:00 p.m.	38.84 ± 0.024	0.26 ± 0.017	0.67 ± 0.044
6:00 p.m.	38.87 ± 0.025	0.27 ± 0.018	0.70 ± 0.046
10:00 p.m.	38.63 ± 0.028	0.30 ± 0.019	0.78 ± 0.057
Diurnal temperature	38.70 ± 0.015	0.32 ± 0.010	0.82 ± 0.011
Nocturnal temperature ..	38.56 ± 0.013	0.20 ± 0.009	0.52 ± 0.025
Average for the day	38.66 ± 0.022	0.31 ± 0.008	0.81 ± 0.022

TABLE 2

The differences of the means of temperatures of Indian Nellore cattle taken at intervals of four hours throughout the entire day of 24 hours

TIME OF DAY	6:00 A. M.	10:00 A. M.	2:00 P. M.	6:00 P. M.	10:00 P. M.
2:00 a. m. 38.49 ± 0.026°C.	$D = 0.028 \pm 0.033$ $\frac{D}{E} = 0.83$ X	$D = 0.120 \pm 0.036$ $\frac{D}{E} = 3.2$ X	$D = 0.356 \pm 0.035$ $\frac{D}{E} = 10.0$ X	$D = 0.384 \pm 0.036$ $\frac{D}{E} = 10.54$ X	$D = 0.144 \pm 0.038$ $\frac{D}{E} = 3.75$ X
6:00 a. m. 38.46 ± 0.020°C.		$D = 0.148 \pm 0.033$ $\frac{D}{E} = 4.4$ X	$D = 0.384 \pm 0.031$ $\frac{D}{E} = 12.0$ X	$D = 0.412 \pm 0.032$ $\frac{D}{E} = 12.5$ X	$D = 0.172 \pm 0.035$ $\frac{D}{E} = 4.9$ X
10:00 a. m. 38.61 ± 0.026°C.			$D = 0.236 \pm 0.035$ $\frac{D}{E} = 6.6$ X	$D = 0.264 \pm 0.036$ $\frac{D}{E} = 7.2$ X	$D = 0.024 \pm 0.038$ $\frac{D}{E} = 0.62$ X
2:00 p. m. 38.84 ± 0.024°C.				$D = 0.28 \pm 0.035$ $\frac{D}{E} = 0.8$ X	$D = 0.122 \pm 0.037$ $\frac{D}{E} = 5.7$ X
6:00 p. m. 38.87 ± 0.025°C.					$D = 0.240 \pm 0.039$ $\frac{D}{E} = 6.3$ X

THE EFFECT OF VARYING AMOUNTS OF SUGAR ADDED TO PINEAPPLE PULP MASH ON ACIDITY AND YIELD OF "NATA DE PIÑA"[1]

L. J. VILLANUEVA
Of the Department of Agricultural Chemistry

In the manufacture of fruit wines and beverages from ripe pineapple fruits, the principal waste products are the pulp, which is obtained after the extraction of the juice, and the peelings. In a pineapple-canning establishment, the trimmings as well as the core, if not pressed for their juice, and peelings are thrown away or fed to animals. All these industrial wastes are known to be suitable for the growth and culture of "nata de piña." Nata de piña is the name given to the firm gelatine-like bacterial growth on macerated or ground ripe pineapple, or other sugary materials.[2]

Nata de piña is a known delicacy which commands a high price when properly sweetened and cooked. It is produced on a commercial scale in Pagsanjan, Laguna, but the method of its culture is kept a secret.

In a private communication,[3] it was disclosed that nata de piña is not produced by *Leuconostoc mesenteroides* (Cientowski) van Tieghem, but by another member of the genus *Leuconostoc*.

The work reported in this paper had for its object the determination of the effect of varying amounts of sugar on the developed acidity of pineapple mash and yield of nata de piña.

REVIEW OF LITERATURE

Ocfemia (1932), in an unpublished report, mentioned a few characteristics of *Leuconostoc* responsible for the growth of nata de piña. He said that it is "saprophytic in nature, growing usually in sugar solutions and many over-ripe fruits." He also observed the mode of

[1] Experiment Station contribution No. 1195. Read before the Division of Chemical and Pharmaceutical Sciences, Fourth Philippine Science Convention, February 23, 1937.

[2] Serrano, Felicisimo B., 1919, cited by Ocfemia (1932), prepared nata de piña by using different fruits. No copy of the thesis is available for reference.

[3] Dr. G. O. Ocfemia, head of the Department of Plant Pathology, states that many authors disagree as to the organism responsible for the growth of nata de piña. Its correct identification is still in question.

formation of the nata de piña as arising from "zoogloeal masses formed by the union of the gelatinous envelopes or capsules made up of a heavy, hyaline, and gelatinous matter believed to be dextran." He further stated that this species of bacteria is the enemy of bakeries in the United States because it causes souring and slimy fermentation of the dough. In the Philippines, it is an enemy of sugar factories in that it is responsible for the slimy fermentation of juices.

Oliveros (1935) pointed out in a general way the precautions that must be observed in successfully making nata de piña, including the care of the "fermenters" and daily examination of the culture media. He recommended the addition of white sugar amounting to 1/20 of the weight of the whole ground pineapple fruit. He also gave brief directions for cooking "nata de piña" for home use.

Wells and his co-workers (1928), in their study of the composition of Philippine pineapples, showed that sucrose and invert sugars increased with an increase in the weight of the fruit. They found that the acidity fluctuated upward as the weight of the fruit increased.

EXPERIMENTAL

Ripe, undersized fruits of Smooth Cayenne from the Department of Agronomy were used in this study. The edible portion of this variety, according to the analyses of Wells and his co-workers (1928), contains 8.25 per cent sucrose, 3.89 per cent invert sugar, and 12.57 per cent total sugars.

Three series were run: the first with over-ripe fruits and the other two with fully ripe ones.

The fruits were peeled and the edible portion cut into small pieces and then ground in a meat grinder. The juice was then extracted by means of a hand press. The residual pulp was then diluted with previously boiled and cooled water up to a consistency lighter than that of the ground pineapple with its own juice. Pineapple mash from which nata had been harvested previously was then added to serve as seed. Five hundred grams of this diluted pulp were then put in 800-ml. beakers, each having a diameter of 9.5 cm. White sugar equivalent to 4, 6, 8, 10, etc., per cent of the weight of the diluted pulp was added. The cultures were then covered with Manila paper, tied with a piece of twine, and set aside on a stable platform in the laboratory. The cultures were examined every day. During the first three days, fermentation was rapid, during which time the mash was stirred with a glass rod to get rid of the gases.

When a film of nata de piña started to form, the culture was left undisturbed, pricking only with a pin those portions of the film which revealed the presence of inclosed gases.

The acidity of the mash was obtained by drawing about 20 mls. of the liquid with a 10-ml. pipette, which was inserted between the wall of the beaker and the film of nata, and by putting the liquid in a 50-ml. beaker and determining the pH with an antimony electrode in pair with a saturated calomel half-cell. The pH of the mash was calculated by using the formula:

$$\mathrm{pH} = \frac{E + 0.005}{0.058}$$

where E = observed electromotive force.

The weight of the nata de piña was determined at harvest time as shown in the table. The thick film was washed three times with water, allowed to drain in a colander, and then weighed.

The average thickness of the nata de piña was determined by taking measurements with a foot-rule along its diameter after the film had been cut in two, and along the edges.

RESULTS AND DISCUSSION

The average moisture content of the freshly harvested nata de piña was 96.04 per cent. The average ash content was 0.058 per cent, or 1.43 per cent based on the dry matter.

The data presented in table 1 represent the averages of duplicate determinations. The amount of sugar added, pH, and weight and thickness of the harvested nata are given.

The pH of the cultures in series A were all below 3.53, except in A_4 where the average was 3.62. The pineapples used in this series were over-ripe. As shown in the table, the pH did not have any effect on the yield. The control yielded an average of 56.6 grams while those in which sugar was added gave yields ranging from 110.8 grams, in A_5 (12 per cent sugar), to 143.1 grams, in A_1 (4 per cent sugar), which are more than twice the yield obtained in the control. The average thickness of the yield in the control was 0.90 cm. against 1.44 cm. to 2.22 cm. in those to which sugar had been added in various amounts.

In series B, the pH of all the cultures on the fourth day were practically the same. At the end of the second week, those to which sugar had been added dropped in pH, showing increased acidity,

while the control remained more or less constant. The same is true after the third week. The drop, however, was more pronounced. The pH of the mash after the addition of the starter was 3.53. The high initial acidity may have been due to acids originally present in the pineapple fruits. The yield in the control was 23.5 grams with an average thickness of 0.36 cm. Those with sugar gave yields ranging from 61.5 grams, corresponding to B_1 (with 4 per cent sugar), to 94.1 grams, corresponding to B_6 (with 14 per cent sugar), or about 3 to 4 times that in the control. The average thickness ranged from 0.96 cm. to 1.30 cm., corresponding to cultures B_1 and B_3, respectively.

Series C followed practically the same trend as in series B, except the control. The pH of the control increased while that of the cultures with sugar decreased, except those of C_1 and C_2 where there was a slight fluctuation during and after the second week up to harvest time. The yield of the control was 34.9 grams, with an average thickness of 0.45 cm., while those with sugar gave yields ranging from 66.0 grams, in C_5 (12 per cent sugar), to 102.4 grams, in C_7 (16 per cent sugar). The average thickness of the yields from cultures in which sugar had been added ranged from 1.53 cm. in C_8 to 1.92 cm. in C_2.

The surface area (exposed) of the cultures in C_6, C_7, and C_8 was greater than that of the other cultures. This difference may be responsible for the variation in the amount of yield, not taking into consideration the depth of the media. A study of this striking difference will be undertaken in the future.

While the pH could not be determined below 3.53, because this figure happens to be the lower limit of the potentiometer used, it was evident that in all cases the addition of sugar produced a lowering of the pH, or an increase in acidity. The amount of sugar added, however, had no relationship with pH lowering, showing that the organism responsible for the production of nata de piña probably requires a certain pH range for its optimum growth, and that it may be capable of modifying the existing conditions to suit its needs for normal growth.

The yield also increased upon the addition of sugar. An increase in the amount of sugar added did not produce a corresponding increase in the yield. This seems to indicate that greater returns can be obtained by adding only the optimum quantity of sugar. In the three series under study, the use of 6 to 10 per cent sugar (which is about the average sugar content of ripe pineapple) would be most profitable for residual pineapple pulp with the proper dilution.

SUMMARY AND CONCLUSIONS

The results obtained in this study tend to show that:

1. Sugar when added to diluted residual pineapple pulp mash increased the yield of nata de piña. The yield from those cultures in which sugar was added was from twice to more than three times that obtained from the control.

2. The concentration of sugar which seemed to give maximum returns was from 6 to 10 per cent which is about the average sugar content of pineapple.

3. While acidity increased upon the addition of sugar, it did not increase directly with the amount added.

4. Although the lower limit of pH determinations could not be ascertained, it seems probable that the organism requires a certain pH range to give the optimum yield of nata de piña. It is also possible that the organism is capable of modifying to some extent conditions in the culture media to suit its normal growth.

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WELLS, A. H., ET AL. 1928. The composition of Philippine pineapples. Philippine Journal of Science **36**: 157–186.

TABLE 1

Amount of sugar added, pH, and weight and average thickness of nata grown on pineapple pulp

Series A [a]

CULTURE NO.	SUGAR ADDED	pH			YIELD	
		8-5-'35	8-13-'35	8-21-'35	Weight	Average thickness
	per cent				*grams*	*cm.*
Control .	—	below 3.53	below 3.53	below 3.53	56.6	.90
A_1	4	" 3.53	" 3.53	" 3.53	143.1	1.94
A_2	6	" 3.53	" 3.53	" 3.53	126.7	2.00
A_3	8	" 3.53	" 3.53	" 3.53	136.8	2.08
A_4	10	3.62	" 3.53	" 3.53	141.0	2.22
A_5	12	below 3.53	" 3.53	" 3.53	110.8	1.44
A_6	14	" 3.53	" 3.53	" 3.53	120.8	1.62
A_7	16	" 3.53	" 3.53	" 3.53	115.0	1.56

[a] Started July 30, 1935.
Harvested Sept. 13, 1935.
Diameter of culture beaker, 9.5 cm.

Series B [a]

CULTURE NO.	SUGAR ADDED	pH			YIELD	
		8-6-'35	8-13-'35	8-21-'35	Weight	Average thickness
	per cent				*grams*	*cm.*
Control .	—	4.33	4.31	4.45	23.5	.36
B_1	4	4.47	3.90	3.84	61.5	.96
B_2	6	4.53	3.74	3.69	78.6	1.14
B_3	8	4.40	3.64	3.60	81.3	1.30
B_4	10	4.53	3.71	3.55	87.4	1.24
B_5	12	4.22	3.53	below 3.53	86.0	1.24
B_6	14	4.34	3.72	3.60	94.1	1.26
B_7	16	4.47	3.86	below 3.53	88.4	1.24

[a] Started Aug. 3, 1935. *pH* of mash after addition of starter, 3.53. Harvested Sept. 13, 1935. Diameter of culture beaker, 9.5 cm.

Series C [a]

CULTURE NO.	SUGAR ADDED	pH				YIELD	
		7-30-'35	8-6-'35	8-13-'35	8-20-'35	Weight	Average thickness
	per cent					*grams*	*cm.*
Control	—	3.88	4.05	4.00	4.91	34.9	.45
C_1	4	4.22	3.83	3.84	4.15	89.3	1.87
C_2	6	4.36	3.57	3.81	3.74	93.6	1.92
C_3	8	4.43	3.76	3.67	3.62	89.9	1.90
C_4	10	4.29	3.79	3.60	3.57	85.5	1.78
C_5	12	4.09	3.83	3.71	3.53	66.0	1.55
C_6	14	4.15	3.64	3.53	3.53	100.2 [b]	1.73
C_7	16	4.28	below 3.53	below 3.53	below 3.53	102.4 [b]	1.68
C_8	18	4.10	3.72	3.62	below 3.53	85.3 [b]	1.53

[a] Started July 26, 1935. Harvested Aug. 20, 1935.

[b] Diameter of culture beakers, 9.5 cm. Rest of beakers were 8.5 cm. inside diameter.

STUDY OF VARIATION AND SELECTION OF SOME LOCAL VARIETIES OF EGGPLANT [1]

CORNELIO B. MACABASCO

WITH ONE TEXT FIGURE

The eggplant (*Solanum melongena* Linn.) is one of the most common vegetable crops in the Philippines, and its fruit is used in various ways for cooking and pickling. It is represented by several varieties which differ in color of the fruit as well as in vegetative and reproductive habits. There are varieties which are preferred by the growers and consumers. If these preferences are supported by cultural habits or inherent qualities of eggplant varieties, improvement of the crop can be placed on a scientific basis. The present investigation is a comparative study of the varietal characteristics of some local eggplants and a selection within and among the varieties as a preliminary step towards improvement.

Review of literature

A survey of the literature on the subject shows that no experimental study on agronomic characters and selection of eggplant varieties has been reported in the Philippines. Bayla (1918) used a Native long variety as one of the parents in hybridization and reported vigor and prolificacy among the F_1 plants. Magtang (1936) studied the floral biology of one of the types of the Philippine Native Long Purple eggplant and concluded that for plant-breeding purposes, this variety may be considered as a self- as well as a cross-pollinating plant. Published works of Kakizaki (1930, 1931) and Jannaki (1933) in Japan, of Nolla (1932) in Puerto Rico, and of Smith (1931) in the United States refer to genetic analysis of races of eggplant, but some of these authors' observations on behavior of flowering and variations in yield have a direct bearing on the present study.

[1] Thesis presented for graduation, 1937, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 1062; Experiment Station contribution No. 1196. Prepared in the Department of Agronomy under the direction of Dr. José M. Capinpin.

Objects of the present work

The present work had for its objects: (*a*) to study the agronomic and plant-breeding characters of seven varieties of eggplants commonly grown in the province of Laguna and (*b*) to isolate the types or varieties of these eggplants that may be found desirable for future improvement.

Time and place

The work was carried out in the plant breeding laboratory of the Department of Agronomy and at the Experiment Station grounds, College of Agriculture, from November, 1934, to September, 1936, a period of two years.

MATERIALS AND METHODS

Varieties used. Seeds of seven fairly well established varieties of eggplant were secured as per tabulation below and planted in November, 1934:

Varieties	*Source of seeds*
Los Baños Black Purple	College Coffee Plantation, Agric. College, Laguna
Binayag Toro	College Coffee Plantation, Agric. College, Laguna
Small Native Purple	Maahas, Los Baños, Laguna
Sinanpiro	Maahas, Los Baños, Laguna
Short Sinanpiro	Maahas, Los Baños, Laguna
Americano	Pakil, Laguna
Pakil Black Purple	Pakil, Laguna

The seeds of Los Baños Black Purple and of Binayag Toro varieties of eggplant were obtained from a tenant at the College Coffee Plantation; those of the Small Native Purple, from a farmer at Maahas, Los Baños, Laguna; of Short Sinanpiro and Sinanpiro, from ripe fruits given by another farmer residing in Maahas, Los Baños, Laguna; and of Americano and Pakil Black Purple, from ripe fruits from Pakil, Laguna.

Sowing. The seeds were sown separately in seed boxes, and the susceptibility of the seedlings of each variety to diseases was observed. The date of sowing for the first planting was November 24, 1934, and for the second planting, October 1, 1935.

Pricking. The seedlings were pricked twenty-four days after sowing.

Setting in the field.—The seedlings of the first culture were set in the fields fifty-five days after sowing, and of the second culture,

fifty-four days after sowing. In both cases, the leaves of the seedlings were about as large as a fifty-centavo piece at the time of planting. The distance of planting was seventy-five centimeters between plants in the row and one meter between the rows. In all cases one-hundred seedlings for each variety were planted.

Care. The seedlings, after being set, were watered. Watering continued for a time until the plants had become well established. Weeding and cultivation were resorted to whenever necessary.

Agronomic characters and plant-breeding value. The study of the plant-breeding value of the different local eggplant varieties was based on the following agronomic characters:

(*1*) *Height of the plants.* All the plants of each of the seven local eggplant varieties were measured with the use of a meter stick on a day when the varieties were fruiting heavily. The variation constants for the height of each variety were then determined.

(*2*) *Lateral expansion of the plants.* The lateral expansion of the plants of each variety was taken on the same day their height was measured.

(*3*) *Time of flowering and fruiting.* Daily inspection of the plants was made, and the plants bearing the first flower bud were labeled. The dates of the appearance of the first flower bud, its opening and fruit setting, and harvesting of the fruit for seeds were recorded.

(*4*) *Branching habit of the varieties.* Observations were made on branching habits, whether erect or drooping, of each variety at the time the plants were heavily loaded with fruits.

(*5*) *Size of the leaves.* Measurements of the leaves were taken when the varieties were at the height of the fruiting season. The length was measured from the base to the tip of the leaf blade, while the width was taken at the widest portion of the leaf blade.

(*6*) *Weight of the fruits.* The peduncles were severed from individual fruits at the base of the calyx, and the fruits proper were weighed separately in a Cenco balance accurate to one-tenth of a gram.

(*7*) *Size of the fruits.* The size of the fruits of each variety was determined in the laboratory. The peduncles of the fruits were first severed from the base of the calyx, and from this end to the stigmatic point, a small wire was extended midway. The wire was later stretched along the ruler. The measurement taken represented the length of the fruit. The diameter was taken by measuring each fruit at its largest portion with the aid of a caliper.

(*8*) *Seediness of the fruits of each variety.* Seediness of a fruit was determined by dividing the weight of well developed dried seeds by the weight of the ripe fruit. The resulting quotient multiplied by 100 expresses the seediness of a fruit in per cent.

(*9*) *Quality of the fruits.* The eating quality of the fruits of the different varieties was determined from the reports of students who were given three or more fruits of each variety with the request that they cook and eat them and inform the writer on their sweetness and tenderness. To check these reports, the writer himself made personal tests.

(*10*) *Toughness of the fruits.* Fruits of each variety of about the same marketable age were pressed between the thumb and forefinger. If the fruit had the tendency to give way to the pressure, it was considered flabby; if not, tough.

(*11*) *Resistance to pests and diseases.* The resistance of the varieties was determined by keeping a weekly record of the number of plants found living from the time the seedlings were planted, adding together the weekly number of living plants recorded, and dividing the sum by the number of weeks of observation. The quotient expressed the resistance of the variety in per cent because, as already stated, one hundred plants were originally set in the field.

(*12*) *Yield.* The fruits harvested for each variety were weighed on a Cenco balance. The total weight of the fruits at the end of the fruiting season was taken as the yield of the variety. The sum divided by the average number of living plants during the fruiting season represented the average yield per plant of each variety. In the second planting separate records of the yield of individual plants of each variety were kept.

(*13*) *Other plant-breeding characters.* The shape and color of the fruit, the abundance of the spines on the calyx, the number and color of the petals, sepals, and stamens of the flowers, and the position of the styles in the flowers of each variety were studied both in the field and in the laboratory.

Selection within and among the varieties. In the first planting, the characters of the seven varieties were studied and were compared for their plant-breeding value. The selection among these varieties was largely based on the yield and resistance to diseases. Individual selection was made in the second planting. The bases of selection were yield, early flowering, and size of the plants.

RESULTS OF THE EXPERIMENTS

Tables 1 to 1f present the variability in the agronomic characters of the eggplant varieties.

Table 2 presents the results of the observations made on the first flower bud formed and the first fruit set therefrom.

DISCUSSION OF RESULTS

In the first culture, variety Los Baños Black Purple showed signs of germination on the seventh day from date of sowing; Binayag Toro, Americano, and Pakil Black Purple, on the eighth day; Small Native Purple, on the ninth day; and Short Sinanpiro and Sinanpiro, on the tenth day. On December 18, 1934, all the seedlings were pricked, and on January 19, they were set out in the field. In the seed box, varieties Los Baños Black Purple, Binayag Toro, and Sinanpiro were attacked by seedling blight.

Agronomic characters of the seven local varieties

The agronomic characters of the seven varieties varied in many respects. The average height ranged from 23.78 centimeters for Small Native Purple to 41.17 centimeters for Pakil Black Purple. The plants differed also in lateral expansion; the Sinanpiro variety showed the greater spread. In mode of branching Los Baños Black Purple, Short Sinanpiro, Americano, and Pakil Black Purple were noted to have a tendency to grow upright, while the branches of Small Native Purple and Sinanpiro had a tendency to droop. The branches of Binayag Toro were inclined to crawl on the ground.

Varietal characteristics were also noted in flowers and in fruits. The flowers of Los Baños Black Purple, Small Native Purple, Sinanpiro, and Pakil Black Purple were of light lobelia violet color.[2] The other three varieties, Binayag Toro, Short Sinanpiro, and Americano, had lobelia violet color. Variations were also found in color and number of petals, number of anthers, and in color of pedicels.

The fruits of Los Baños Black Purple and Pakil Black Purple were darker than those of Small Native Purple, Short Sinanpiro, and Sinanpiro. All these purple varieties had either a few or a large number of green splashes. Binayag Toro and Americano had pale yellowish skin. The latter had white stripings toward the apical end of the fruit.

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[2] RIDGWAY, R. 1912. Color standards and color nomenclature. iii + 43 p. *53 colored plates.* Baltimore, Md.: A. Hoen and Company.

Variability in agronomic characters of the seven local eggplant varieties

By referring to tables 1, 1a, 1b, 1c, 1d, 1e, and 1f, one may note a great deal of variation in the time required by the different varieties to reach the stage of formation of the first flower bud. The most variable variety was Pakil Black Purple (table 1f). It had a mean of 78.25 ± 1.76 days from the time of planting and a coefficient of variation of 29.68 ± 1.76 per cent. The least variable was Short Sinanpiro (table 1c), with a mean of 82.98 ± 1.56 days, and a coefficient of variation of 22.42 ± 1.46 per cent. In this comparison, variety Los Baños Black Purple (table 1) was used as the standard.

The fruits of the varieties showed variations in length of time required to mature. The coefficients of variation for this character were: for Los Baños Black Purple, 3.14 ± 0.50; Binayag Toro, 3.14 ± 0.50; Small Native Purple, 9.56 ± 1.36; Short Sinanpiro, 10.43 ± 1.45; Sinanpiro, 11.88 ± 1.28; Americano, 8.93 ± 1.06; and Pakil Black Purple, 8.65 ± 1.19 per cent. The mean length of time required for the fruits to mature was: Los Baños Black Purple, 45 ± 0.32; Binayag Toro, 41.00 ± 0.32; Small Native Purple, 37.33 ± 71.89; Short Sinanpiro, 39.75 ± 0.78; Sinanpiro, 39.6 ± 0.71; Americano, 40.88 ± 0.62; and Pakil Black Purple, 42.75 ± 0.59 days. The most variable was Sinanpiro. These variations, however, should not be taken as final because of the writer's failure to fix a standard shade whereby a fruit on the stage of ripening was considered mature.

The varieties also differed in height. Sinanpiro was the most variable with a coefficient of variation of 36.47 ± 2.64 per cent from the mean height of 30.09 ± 1.00 centimeters. The least variable was Binayag Toro. The variation coefficient was 18.46 ± 2.63 per cent from the mean height of 28.08 ± 0.9 centimeters. The mean height of Los Baños Black Purple, used as the standard for comparison, was 33.67 ± 1.55 with a coefficient of variation of 26.51 ± 3.49 per cent.

In spread of plants, Binayag Toro was the most variable as compared with Los Baños Black Purple. The mean spread of the plants of Binayag Toro was 41.00 ± 3.54 centimeters, and a coefficient of variation of 46.30 ± 7.62 per cent. The least variable variety as compared with Los Baños Black Purple was Small Native Purple which had a mean height of 23.78 ± 0.73 centimeters and coefficient of variation of 21.88 ± 2.28 per cent.

Variations were also observed in the size of the leaves. The coefficients of variation in the length of the leaves were: for

Los Baños Black Purple, 14.41 ± 0.98 per cent; Binayag Toro, 14.70 ± 1.08 per cent; Small Native Purple, 15.37 ± 0.75 per cent; Short Sinanpiro, 11.25 ± 0.54 per cent; Sinanpiro, 16.14 ± 0.79; Americano, 13.06 ± 0.63; and Pakil Black Purple, 14.04 ± 0.68. The mean lengths of the leaves in centimeters for the seven varieties were: Los Baños Black Purple, 19.88 ± 0.30; Binayag Toro, 15.59 ± 0.23; Small Native Purple, 11.06 ± 0.11; Short Sinanpiro, 15.41 ± 0.12; Sinanpiro, 15.31 ± 0.17; Americano, 16.88 ± 0.14; and Pakil Black Purple, 16.63 ± 0.18. With Los Baños Black Purple as the standard for comparison, the figures show that the variety with the greatest departure from the mean was Sinanpiro, and the least departure, Small Native Purple.

In the width of the leaves, the coefficients of variation were as follows: Los Baños Black Purple, 19.96 ± 1.54 per cent; Binayag Toro, 18.65 ± 1.38; Small Native Purple, 18.71 ± 0.92; Short Sinanpiro, 13.92 ± 0.88; Sinanpiro, 19.15 ± 0.97; Americano, 16.44 ± 0.73; and Pakil Black Purple, 16.24 ± 0.79.

The mean widths of the leaves of the varieties in centimeters were: Los Baños Black Purple, 11.37 ± 0.25; Binayag Toro, 11.37 ± 0.21; Small Native Purple, 7.78 ± 0.10; Short Sinanpiro, 10.84 ± 0.10; Sinanpiro, 10.61 ± 0.14; Americano, 11.37 ± 0.13; and Pakil Black Purple, 11.12 ± 0.12 centimeters. The figures show that the seven varieties studied as compared to Los Baños Black Purple were less variable in width of the leaves.

The mean weight of the fruits used as vegetables of variety Los Baños Black Purple was 63.55 ± 2.77 grams with a coefficient of variation of 25.89 ± 3.29 per cent; Binayag Toro, 77.48 ± 1.58 grams with a coefficient of variation of 11.74 ± 1.47 per cent; small Native Purple 20.30 ± 1.34 grams with a coefficient of variation of 29.90 ± 5.16 per cent; Short Sinanpiro, 32.86 ± 1.23 grams, with a coefficient of 27.77 ± 2.84 per cent; Sinanpiro, 46.00 ± 1.04 with 24.20 ± 1.69 per cent; Americano, 61.38 ± 1.77 grams with a coefficient of variation of 30.06 ± 4.27 per cent; and Pakil Black Purple, 52.60 ± 1.92 grams with a coefficient of variation of 35.89 ± 2.97 per cent. From the figures, it will be noted that Pakil Black Purple was the most variable and variety Binayag Toro the least variable.

Variety Pakil Black Purple was also the most variable in point of weight of ripe fruits, and Short Sinanpiro, the least. The mean weight of ripe fruits of Los Baños Black Purple was 90.13 ± 3.97 grams, with a coefficient of variation of 38.69 ± 3.55 per cent; Pakil

Black Purple, 100.46 ± 4.95 grams, with a coefficient of variation of 23.11 ± 3.67 per cent; and Sinanpiro, 79.79 ± 1.77 grams, with a coefficient of variation of 29.64 ± 1.64 per cent.

Variability in length and diameter of fruits was also prominently exhibited by the varieties. The most variable in length of fruit as vegetable was Americano with a mean length of 9.46 ± 0.16 centimeters and a coefficient of variation of 17.91 ± 1.23 per cent. The least variable was Binayag Toro which had a mean of 6.86 ± 0.07 and a coefficient of variation of 5.94 ± 0.73 per cent.

The least variable in length of ripe fruit was also Binayag Toro with a mean of 7.27 ± 0.19 centimeters and a coefficient of variation of 12.52 ± 1.92 per cent. The other five varieties were also not very variable. The standard used for comparison was Los Baños Black Purple.

In the diameter of fruits as vegetables, the variety showing the widest variability was Small Native Purple. It had a mean of 2.18 ± 0.09 centimeters and a variation of 18.19 ± 2.89 per cent. The other five varieties were also more variable than Los Baños Black Purple, the standard for comparison.

The most variable in diameter of ripe fruits was Pakil Black Purple. It had a mean diameter of 3.77 ± 0.06 centimeters and a coefficient of variation of 16.24 ± 1.37. The least variable was Small Native Purple. Its mean diameter was 2.77 ± 0.4 centimeters with a coefficient of variation of 5.75 ± 0.91 per cent. Los Baños Black Purple was used as the standard for comparison.

Pakil Black Purple was the least variable when seediness of the fruits was considered. It had a mean weight of 4.71 ± 0.16 grams and a coefficient of variation of 2.4 ± 0.38 per cent. The other six varieties each had its coefficient of variation less than that of Los Baños Black Purple which was used here as the standard for comparison.

Observations on the first flowers and first fruits

Referring to table 2, it is seen that of the 30 first flower buds observed in variety Los Baños Black Purple of which 86.87 per cent had opened, 79.23 per cent of the buds opening set into fruit buds, and 27.78 per cent of the flowers setting into fruit buds continued to mature. The percentages of flowers opening for different varieties were: for Binayag Toro, 82.75 per cent; Small Native Purple, 84.78; Short Sinanpiro, 93.33; Sinanpiro, 96.05; Americano, 91.89; and Pakil Black Purple, 67.65. These show that more flower buds opened in

varieties Sinanpiro, Short Sinanpiro, and Americano, and less buds opened in varieties Binayag Toro, Small Native Purple, and Pakil Black Purple. The standard used for comparison was Los Baños Black Purple.

The higher percentage of flowers setting into fruit buds was in variety Binayag Toro. In variety Americano the percentage was very low. The variety used as the standard for comparison was Los Baños Black Purple.

The percentage of fruit maturing was highest in variety Sinanpiro. The percentage was 44.44 per cent. The second and third highest were varieties Americano, 39.15 per cent, and Short Sinanpiro, 28.58 per cent. Varieties Binayag Toro and Pakil Black Purple had lower percentages. The lowest was 16.00 per cent for small Native Purple. Variety Los Baños Purple was used as the standard for comparison.

Weekly harvests

The fruiting season began on May 7, 1935, and ended on July 16, of the same year. There was not a definite date for the height of the fruiting season for all the varieties. The yield fluctuated from week to week. This phenomenon may be explained by the general tendency of the flowers to abscise after a heavy rain during hot, sunny days. Most of the fruits were harvested between June 4 and July 9.

The average total yield per plant of Los Baños Black Purple was 161.08 grams. The varieties yielding more than Los Baños Black Purple per plant were: Sinanpiro, with an average total yield of 205.82 grams, and Binayag Toro, with an average total yield of 201.75 grams. The varieties yielding lower than the standard set for comparison were: Small Native Purple, 35.38 grams; Short Sinanpiro, 100.76; Americano, 111.97; and Pakil Black Purple, 103.19 grams. Those represent average total yield per plant.[3]

In number of fruits, variety Sinanpiro yielded a total of about four and one-half as many as that of Los Baños Black Purple; Americano, two and one-half times; and Pakil Black Purple and Short Sinanpiro, about two times. The yields of Sinanpiro, Americano, and Pakil Black Purple were respectively as follows: 230, 128, and 104 fruits. Binayag Toro produced about two-thirds as many fruits as Los Baños Black Purple had.

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[3] Harvesting was ended on July 16, 1935, because the fruits produced after that date were few and small.

Early flowering as expressed in number of days from the time of sowing to the appearance of the first flower bud is a desirable trait of an eggplant. Los Baños Black Purple had its first flower bud on the average of 68 days from the time of planting or 123 days after sowing. The other varieties compared with this were later flowering.

Maturity of the fruits is expressed by the number of days from the date the flowers set into fruit buds to the date when the fruits began to turn yellow. The fruits of Los Baños Black Purple matured on the average in 45 days. The fruits of the other varieties matured from 2 to 8 days earlier than this average. The fruits of Small Native Purple matured earliest among the seven varieties studied.

The average length of fruits as vegetable of Pakil Black Purple was 15.3 centimeters. This length was greater than either the average length of Los Baños Black Purple or Sinanpiro. The average length of fruits as vegetable of either Binayag Toro, Small Native Purple, Short Sinanpiro, or Americano was from 1.8 to 7.8 centimeters shorter than the average length of fruits as vegetable of Los Baños Black Purple. The greatest length for ripe fruits was for Sinanpiro and Pakil Purple varieties. The length was 16.5 centimeters, or 1.6 centimeters longer than the average length of Los Baños Black Purple. The lengths of the four varieties, Binayag Toro, Americano, Small Native Purple, and Short Sinanpiro were from three-tenths of a centimeter to 7.6 centimeters shorter than the average length of ripe fruits of Los Baños Black Purple. The greatest diameter of fruits of Binayag Toro averaged 5.62 centimeters, and of Americano, 3.98 centimeters. Both diameters were greater than the diameter of the Los Baños Black Purple. The varieties which had smaller diameters than Los Baños Black Purple were Small Native Purple, Short Sinanpiro, and Pakil Black Purple.

The greatest diameter of ripe fruits of Binayag Toro averaged 6.05 centimeters, and of Americano, 4.45 centimeters. Both widths were greater than the average diameter of ripe fruits of Los Baños Black Purple. Each of the four other varieties had a smaller diameter than Los Baños Black Purple. In width of fruits Binayag Toro should be given first consideration in the selection; Americano, second; and Los Baños Black Purple, third.

The heaviest average weight of fruits ready for table use was 77.48 grams for Binayag Toro. It was heavier than the average weight of fruits for variety Los Baños Black Purple. The fruits of

the other varieties weighed less than the average weight of the fruits of Los Baños Black Purple. In weight of fruits for table use, the first three varieties that should be considered are: first, Binayag Toro; second, Los Baños Black Purple, and third, Americano.

The fruit of Binayag Toro was rather globular, and that of Americano, rather cylindrical. The fruits of the other varieties were elongated, slender, and curving.

The shape of fruits is quite an important factor affecting the market value of eggplant. An eggplant fruit, should be straight,

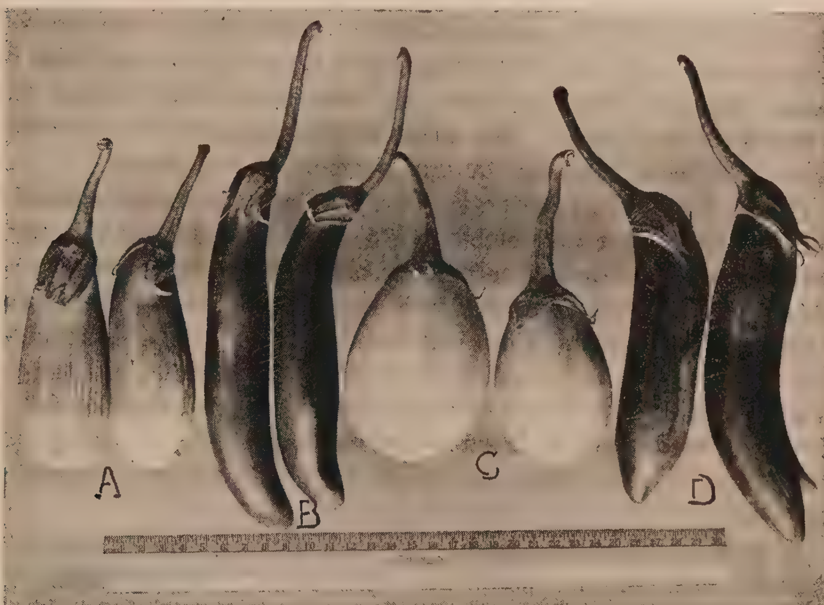

Fig. 1.—Relative sizes and shapes of fruits and shades of color of fruits and peduncles of four eggplant varieties: *A*, Americano variety; *B*, Sinanpiro; *C*, Binayag Toro; and *D*, Los Baños Black Purple. (Photographed on September 10, 1936.)

for fruits which are curved occupy more space in the crates or sacks, and in general, look much shorter than they really are.

The colors of the fruit of Small Native Purple, Short Sinanpiro, and Sinanpiro were lighter than the purple color of Los Baños Black Purple. On the other hand, Pakil Black Purple had a darker shade than Small Native Purple, Short Sinanpiro, or Sinanpiro, but had a lighter shade than Los Baños Black Purple. The color of the fruit of Binayag Toro was pale yellowish green, and of Americano, pale yellowish green, striped at the apical end with white.

At present, there seems to be a prevailing tendency among some people to prefer the purple varieties to any of the other eggplant fruits which have a different color.

The amount of seeds varies among eggplant varieties. The Los Baños Black Purple was the least seedy of all varieties studied. It was found that the six other varieties of eggplant had more seeds than Los Baños Black Purple. The second and third less seedy fruits were Pakil Black Purple and Sinanpiro.

Toughness of fruits is desirable when it comes to marketing. A tough fruit stands more rough handling than a soft one. The fruit of Los Baños Black Purple was flabby. With this as the standard for comparison, the other purple varieties showed no appreciable difference. Varieties Binayag Toro and Americano were tougher than Los Baños Black Purple. The latter two varieties should, therefore, be given first consideration for improvement of toughness.

Cooking quality of the fruit is another point to be considered in selection. Culpepper and Moon (1933) said that during the period at which the fruit would likely be used on the table, its age (35 to 45 days) is correlated with only very small differences in percentage of astringent materials. They claimed, too, that there was a tendency for the acidity to be lowest in fruit at the table stage. In the present study, the writer found out that fruit about four weeks old had rather hard seeds, and fruit six weeks old had a skin turning yellow. Fifty-six day old fruit was observed to have skin almost or completely yellow.

In testing the eating quality of each variety, the writer found that fruits with very soft seeds were preferred by the students. The following were the results gathered in this phase of the experiment: Los Baños Black Purple was tender but rather flat; Binayag Toro, mealy rather than firm and sweet; Small Native Purple, tender and of good taste; Short Sinanpiro, tender and of good flavor; Sinanpiro, tender, fleshy, and of good flavor; Americano, rather juicy and sweet, and Pakil Black Purple, rather fleshy and tender, but quite dry.

Desirability of characters

Height. Fruits borne far off the ground are more desirable than those that are borne low as the former are less soiled when hard rains fall. Soil lodging on the fruit helps start diseases.

The mean height of Los Baños Black Purple was 33.67 ± 1.55 centimeters; Binayag Toro, 28.08 ± 0.97 centimeters; Small Native

Purple, 23.78 ±0.73 centimeters; Short Sinanpiro, 28.05 ± 1.01 centimeters; Sinanpiro, 30.09 ± 1.00 centimeters; Americano, 37.00 ± 0.76 centimeters; and Pakil Black Purple was significantly higher than Binayag Toro, Small Native Purple, and Short Sinanpiro. It was, however, significantly lower than the height of Pakil Black Purple and Americano.

Lateral expansion. A good eggplant variety must have not only height but also lateral expansion. Spreading plants have greater capacity to bear fruits than tall, slender ones.

The mean measurements in centimeters of lateral expansion were: for Los Baños Black Purple, 43.00 ± 2.86; Binayag Toro, 41.00 ± 3.54; Small Native Purple, 29.96 ± 1.35; Short Sinanpiro, 42.08 ± 1.98; Sinanpiro, 55.65 ± 2.42; Americano, 52.00 ± 1.54; and Pakil Black Purple, 54.48 ± 2.08.

The lateral expansion of Los Baños Black Purple was significantly greater than that of Small Native Purple but significantly less than that of either Sinanpiro or Pakil Black Purple. It was broader than that of either Binayag Toro or Short Sinanpiro, but narrower than that of Americano. The differences were not significant.

Size of leaves. The mean length of the leaves of Los Baños Black Purple was 19.88 ± 0.30 centimeters; Binayag Toro, 15.59 ± 0.23; Small Native Purple, 11.06 ± 0.11; Short Sinanpiro, 15.40 ± 0.12; Sinanpiro, 15.31 ± 0.17; Americano, 16.19 ± 0.14; and Pakil Black Purple, 16.63 ± 0.16 centimeters. The difference in length between Los Baños Black Purple and that of any of the other varieties was decidedly in favor of the former. The leaves of Los Baños Black Purple were significantly wider than those of Small Native Purple, Sinanpiro, and Short Sinanpiro, and slightly wider than those of Binayag Toro, Americano, and Pakil Black Purple.

Earliness of flowering. Early flowering is a good varietal trait. Los Baños Black Purple flowered in 68.03 ± 2.12 days after planting; Binayag Toro, in 72.32 ± 2.30 days; Small Native Purple, in 87.38 ± 2.43 days; Short Sinanpiro, 82.98 ± 1.56 days; Sinanpiro, 76.19 ± 1.59 days; Americano, 81.90 ± 1.34 days, and Pakil Black Purple, 78.25 ± 1.76 days. Small Native Purple, Short Sinanpiro, and Americano were decidedly later in flowering than Los Baños Black Purple. Pakil Black Purple and Sinanpiro varieties were significantly later in flowering than Los Baños Black Purple. Binayag Toro flowered later than Los Baños Black Purple, but the difference was not significant.

Maturity of fruits. A fruit is considered ripe when it is turning yellow. The following figures computed from the time the petals withered to the time the fruits began to turn yellow were obtained from this study: for Los Baños Black Purple, 45.00 ± 0.32 days; Binayag Toro, 41.00 ± 0.32 days; Small Native Purple, 37.33 ± 0.72 days; Short Sinanpiro, 39.75 ± 0.76 days; Sinanpiro, 39.60 ± 0.71 days; Americano, 40.88 ± 0.62 days; and Pakil Black Purple, 42.75 ± 0.59 days.

The fruits of Binayag Toro, Small Native Purple, Short Sinanpiro, Sinanpiro, and Americano matured very significantly earlier and the fruit of Pakil Black Purple significantly earlier than those of Los Baños Black Purple. The earlier maturing fruit was of the Small Native Purple, and next was Short Sinanpiro.

Size of the fruits as vegetable. At present, size counts more than weight in our market. Among the seven varieties studied, the three that produced the longest fruit were: first, Pakil Black Purple; second, Sinanpiro; and third, Los Baños Black Purple. Pakil Black Purple fruit measured 15.34 ± 0.27 centimeters from the base of the calyx to the stigmatic point. This measurement was insignificantly longer than that of the fruit of Los Baños Black Purple. The fruit of Sinanpiro was not significantly longer than that of Los Baños Black Purple. The mean length of the fruit of Binayag Toro and Americano was decidedly less than that of Los Baños Black Purple. The diameter of each of the fruits of Small Native Purple, Short Sinanpiro, Sinanpiro, and Pakil Black Purple was significantly less than that of Los Baños Black Purple.

Weight of the fruits as vegetable. In the marketing of vegetables at present, weight is coming into consideration. Desirable eggplant varieties, therefore, must bear fruits of heavy weight. The following were the average weights in grams of eggplant fruit ready for use: for Los Baños Black Purple, 63.55 ± 2.77; Binayag Toro, 77.48 ± 1.58; Small Native Purple, 20.30 ± 1.34; Short Sinanpiro, 32.86 ± 1.23; Sinanpiro, 46.00 ± 1.04; Americano, 61.38 ± 1.78; and Pakil Black Purple, 52.60 ± 1.92. The difference between the mean weight of the fruit of Los Baños Black Purple and that of Small Native Purple and Short Sinanpiro was decidedly significant in favor of Los Baños Black Purple. This weight was also very significantly greater than that of Sinanpiro, and of Pakil Black Purple, but significantly smaller than that of Binayag Toro. The fruit of Los Baños Black Purple was heavier than that of Americano. The difference was not, however, significant.

Size and weight of ripe fruits. With all factors remaining the same, size and weight of ripe fruits are better criteria than the size and weight of fruits at the vegetable stage in determining the desirability of these characters in any given variety, because a ripe fruit has ceased growing and measurements taken from it are more nearly constant. It was noted that Pakil Black Purple had the longest fruit, next Sinanpiro, and then Los Baños Black Purple. Neither Pakil Black Purple fruit nor Sinanpiro fruit was significantly longer than that of Los Baños Black Purple. The average length of Los Baños Black Purple fruit was 14.90 ± 1.67 centimeters.

Binayag Toro fruit had the largest diameter among the fruits of all the varieties. The fruit of Americano ranked second, and Los Baños Black Purple, third. The difference between the diameters of the Los Baños Black Purple fruit and the Binayag Toro and Americano was not significant. The average diameter of the fruit of Los Baños Black Purple was 4.02 ± 0.10 centimeters.

The three varieties which produced the heaviest fruits were: first, Los Baños Black Purple, 106.20 ± 7.26 grams; second, Binayag Toro, 100.46 ± 4.95 grams; and third, Pakil Black Purple, 90.13 ± 3.97 grams. The differences between any of these weights were not significant.

Percentage of seeds in ripe fruit. The method of determining the seediness of a variety was mentioned earlier in this paper. The proportion of the weight of seeds to the weight of ripe fruits of Los Baños Black Purple was about 1:25 or, to be exact, 4.00 ± 0.32 per cent. The percentage in Pakil Black Purple was 4.71 ± 0.23. Pakil Black Purple fruit was insignificantly more seedy than Los Baños Black Purple. Varieties Small Native Purple, Binayag Toro, Short Sinanpiro, and Sinanpiro were significantly more seedy than Los Baños Black Purple.

Other observations

Diseases. On December 12, 1934, a few seedlings of varieties Los Baños Black Purple, Short Sinanpiro, and Binayag Toro were observed to have water-soaked leaves. These were taken to the Plant Pathology Department, College of Agriculture, and the malady was identified as a blight of seedling caused by *Phyllosticta hortorum* Speg. In the field the disease was also observed on twigs and fruits.

The most serious disease attacking the plants in the field was a stem rot. Young plants were brought into the Pathology Department for identification of the causal agent. On January 28, 1935,

the disease was attributed to a fungus called *Sclerotium rolfsii* Sacc. The same organism was identified on February 26, 1935. The writer believes that the decaying grasses and a few corn stalks found buried in the ground were partly to blame for the infection.

Insect pests. The most common insect found among the plants was an unidentified leaf-hopper. It fed on the under-surface of the leaves and gave the plants a blight-like appearance.

On fruit, the most common insect was *Caenocoris inermipes* Stal., family Lygaeidae, order Hemiptera. Both nymphs and adults fed on maturing fruit and caused the rapid rotting of fruits.

Another insect observed was an unidentified tineid leaf-miner. It caused blight-like appearance on the plants. It was not as serious a pest as the leaf-hopper. These various insects were found on the plants of all the varieties.

Resistance of the varieties to pests and diseases. It was observed that the most resistant variety was Americano. The percentage of survival of this plant from planting to the end of the experiment was 89.13 per cent. The percentage of survival of the Los Baños variety was only 45.42 per cent. The other varieties; Sinanpiro, Pakil Black Purple, Short Sinanpiro, and Small Native Purple were more resistant than Los Baños Black Purple. The least resistant variety was Binayag Toro which had a survival of 43.50 per cent.

After having studied the cultural characters and inherent qualities of the seven varieties of eggplant here reported, the writer selected three varieties as desirable material for future improvement. These varieties were Los Baños Black Purple, Sinanpiro, and Americano. The seeds from these varieties were sown in seed boxes on October 1, 1935. Additional characters of the individual plants are here described.

Comparative characters of individual plants of the selected varieties

Height of the plants. The mean height of plants of the Los Baños Black Purple variety was 39.84 ± 0.51 centimeters. Of the total of 86 plants measured, eighteen were between 34.2 centimeters and 39.2 centimeters; twenty, between 39.3 and 44.3 centimeters; and twenty fell between the range of 44.4 and 49.4 centimeters. Six plants had a height greater than 49.4 centimeters. Twenty-two plants had a height below 34.2 centimeters. The mean height of the

plants of variety Los Baños Black Purple in the first planting was 33.67 ± 1.55 centimeters.

In variety Sinanpiro, the mean height of plants was 33.58 centimeters. Of the 93 plants studied, twenty were between 26.2 and 31.2 centimeters; twenty, between 31.3 and 36.3 centimeters; and fifteen between 36.4 and 41.4 centimeters.

It may be noted that varieties Los Baños Black Purple and Sinanpiro in the first planting were shorter than in the second planting. This may be accounted for by the fact that the field used in the second planting was very recently planted to soybeans, and the longer standing period of the plants. In variety Americano, the reverse occurred. This may have been due to the stunting effect of dry weather during the summer. It should also be remembered here that the variety was introduced from Pakil, Laguna.

Spread of the plants. The mean spread of plants of variety Los Baños Black Purple was 79.94 centimeters. Of the 86 plants measured, twenty fell between the range of 73.3 and 83.3 centimeters; fifteen, between 63.2 and 73.2 centimeters; and another fifteen, between 83.4 and 93.4 centimeters. Twenty of the remaining plants had a height above 93.4 centimeters, and the rest had a height below 62.3 centimeters. The average spread of the variety in the first planting was 43.00 ± 2.86 centimeters.

The spread of the plants of the Sinanpiro variety was 76.87 centimeters. Of the 92 plants studied, nine plants had an average height of 45 centimeters; nine, 55.1 centimeters; eleven, 65.2 centimeters; twenty-eight, 75.3 centimeters; twenty, 85.4 centimeters; and four, 95.5 centimeters. The other twelve plants had a spread greater than 100.6 centimeters. The mean spread of the variety in the first planting was 55.64 ± 2.42 centimeters.

The mean spread of the plants for Americano was 67.2 centimeters. Sixteen of the 89 plants studied fell between the class range of 66.4 and 76.4 centimeters. Forty-two plants measured below 66.4 centimeters and thirty-one plants measured above 76.4 centimeters. The average spread of the variety in the first planting was 52.00 ± 1.54 centimeters.

The differences in height of the varieties in the first and the second plantings could be attributed to the same factors as were mentioned in the height of the plants. As for variety Americano, its increased spread in the second planting could be attributed to the long standing period of the plants and to the new shoots formed on the drooping branches during the rainy season.

In general, the spread of plants of Los Baños Black Purple was better than that of the Sinanpiro. The degree of difference, however, was not significant. Compared with the mean spread of plants of the variety Americano, the spread of Los Baños Black Purple variety was significantly greater.

Weight of fruits per plants. The average weight of fruits per plant of the Los Baños Black Purple variety was 431.05 grams. Of the 87 plants that fruited, nine plants had an average yield of 105.5 grams; thirteen, 225.6 grams; twenty-four, 345.7 grams; sixteen, 465.8 grams; twelve, 585.9 grams; five, 706.0 grams; two, 826.1 grams; one, 946.2 grams; three, 1,066.3 grams; and two, 1,428.6 grams.

The mean weight of fruits per plant of the Sinanpiro variety was 303.95 grams. Of the 94 plants that came to bearing, twenty-three plants averaged a yield of 182.5 grams; twenty-five, a yield of 202.6 grams; nineteen, 322.7 grams; thirteen, 442.8 grams; nine, 562.9 grams; three, 683.0 grams; and two, 803.1 grams.

The average individual plant yield of variety Americano was 182.98 grams. Of the 92 plants that bore fruits, thirty-eight plants averaged a yield below the median.

With the plants of each variety as a whole, the average yield of Los Baños Black Purple in grams was higher than the average yield of Sinanpiro, and significantly greater than that of Americano. The Los Baños Black Purple was used as the standard.

In terms of number of fruits per plant, the mean yield of Los Baños Black Purple was 5.57 ± 0.22; of Sinanpiro, 4.21 ± 0.19; and of Americano, 3.09 ± 0.12. The difference between the average yield of Los Baños Black Purple and that of either Sinanpiro or Americano was significantly in favor of the standard.

Early flowering plants. The first 80 plants of variety Los Baños Black Purple flowered on the average in 167.52 ± 1.81 days. Six of the plants reached maturity, on the average, in 128 days; five, in 138.1 days; seventeen, in 148.2 days; twelve, in 158.3 days; eight, in 168.4 days; and nine in 188.6 days. The other eleven plants had their first flower bud formed in class values in between 188.6 and 239.1 days.

In variety Sinanpiro, the early-maturity period of the first 80 earliest plants was 154.86 ± 0.87 days. Nine of the plants flowered on the average in 131 days; seventeen, in 141.1 days; and twenty-eight of the plants reached flower bud formation later than 151.2 days.

The first eight earliest plants of variety Americano had an average maturity period of 173.83 ± 1.99 days. Five of the plants had their first flower bud, on the average, in 128 days; eight, in 138.1 days; eleven in 148.2 days; five, in 158.3 days; seven, in 168.4 days; twelve, in 178.5 days; and ten, in 188.6 days. The bud formation of the rest of the plants fell within the class values 188.6 and 218.9 days.

As a variety, Los Baños Black Purple in the second planting flowered later than Sinanpiro but earlier than Americano. This relationship was not in agreement with the result of the first planting, and the season may have accounted for the difference.

Comparative study of the size of leaves and fruits, and seediness of the selected varieties

Size of the leaves. The leaves of variety Los Baños Black Purple had an average length of 16.51 ± 0.17 centimeters; of Sinanpiro, 15.86 ± 0.10 centimeters; and of Americano, 13.82 ± 0.11 centimeters. The length of the leaves of Los Baños Black Purple was significantly greater than that of Sinanpiro, and very significantly greater than that of Americano. In the width of leaves, variety Los Baños Black Purple was insignificantly narrower than that of Sinanpiro. Compared with the width of the leaves of Americano, Los Baños Black Purple was significantly broader.

Size of the fruits. The mean length in centimeters of vegetable fruits of Los Baños Purple was 17.47 ± 1.00; of Sinanpiro, 15.96 ± 0.10; and of Americano, 10.35 ± 0.08. Los Baños Black Purple had fruits significantly longer than the fruits of Sinanpiro, and decidedly longer than those of Americano.

The mean diameters of vegetable fruits for the three varieties were as follows: Los Baños Black Purple, 3.70 ± 0.02 centimeters; Sinanpiro, 3.08 ± 0.17 centimeters; and Americano, 4.04 ± 0.04 centimeters. The difference between the diameters of Los Baños Black Purple and Sinanpiro was significantly in favor of the Los Baños Black Purple. Compared with the diameter of the vegetable fruit of variety Americano, Los Baños Black Purple was decidedly smaller.

In length of ripe fruits, Los Baños Black Purple was insignificantly longer than that of Sinanpiro, but decidedly longer than that of Americano. In width, ripe fruits of the Los Baños Black Purple were very significantly broader than those of Sinanpiro, and significantly broader than those of Americano.

Weight of the fruits. The mean weight of fruits at vegetable stage of Los Baños Black Purple was decidedly greater than the mean weight of vegetable fruits of either Sinanpiro or Americano. In weight of ripe fruits, the difference was also in favor of the Los Baños Black Purple but was insignificant.

Weekly distribution of the yield of the three selected eggplant varieties

A fruit for each of the varieties Sinanpiro and Americano was harvested on May 2, 1936. The Sinanpiro fruit was gathered ripe. The fruit of the Americano was from a dying plant.

The first harvest for seeds in variety Los Baños Black Purple was made on May 10, 1936. Next, with a little interruption, on June 6, 1936. It may be said that the yield increased from May 9 to August 8, 1936. From then on to September 12, the yield gradually decreased. For variety Americano, the increase was from June 6. It reached a temporary height on June 27, after which date, weekly harvests continued to drop until July 18. In all the varieties, the height of the fruiting season was in the month of August, 1936.

Study of flowers under field conditions

Labeling eighty-one first flower buds of the individual plants, the writer found out that 55.56 per cent of the flowers opened; 55.56 per cent of the buds opening set into fruits; and 64.0 per cent of the flowers setting continued to develop into ripe fruits. In Sinanpiro, out of ninety-one first flower buds observed, 46.16 per cent reached the blooming period; 66.67 per cent of the buds blooming set into fruits; and 42.86 per cent of the flowers setting developed into mature fruits. In variety Americano, 60.76 per cent of the seventy-nine first flower buds bloomed; 62.52 per cent of the buds opening set into fruit buds; and 43.33 per cent of the fruit buds reached maturity.

The great percentage of the flower buds failing to develop seemed to be due to the absence of rain during the period of bud formation. For over a month, many of the buds persisted on the plants without apparent increase in size. The large percentage of the blossoms falling was caused by the cutting off of the stigma by an unknown agent, by the poor development of the styles, by the seemingly weak joint at the abscission layer, and by heavy rain falling on hot, sunny days.

Smith (1931) reported that under field conditions, 62 per cent of the buds observed dropped from inflorescences of one flower; over eighty-two per cent came from inflorescences of two and three flowers; and ninety-eight and two tenths per cent of the flowers that dropped had short, poorly developed styles. Of one hundred and six blossoms of Los Baños Black Purple, the writer found out that 89.72 per cent of the flowers had styles much longer than the stamens; six and eighty-three hundredths had styles of medium length; and three and ninety-six hundredths had styles shorter than the stamens. In Sinanpiro, 76.67 per cent of one hundred and eleven blossoms had long styles; four and five-tenths per cent had medium styles; and 19.82 per cent had short styles. In Americano, out of one hundred and four flowers, the following were the percentages: long styles, 58.67 per cent; medium styles, 17.29 per cent; and short styles, 24.04 per cent. All the flowers with short styles did not set into fruit.

In size of pedicles, Los Baños Black Purple variety was superior to Sinanpiro and Americano. It had, however, no significant relation to the development of either stamens or styles, nor to abscission of flowers. These observations were corraborated by Smith (1931) and Magtang (1936).

SUMMARY AND CONCLUSIONS

1. The seven local eggplant varieties studied differed in agronomic characters and in plant-breeding value, such as color, shape, and size of fruits, yield, and resistance to pests and diseases.

2. The purple varieties are: Los Baños Black Purple, Small Native Purple, Short Sinanpiro, Sinanpiro, and Pakil Black Purple. The non-purple varieties are Binayag Toro and Americano.

3. The computed yield per plant of the varieties studied and selected were: Sinanpiro, 205.82 grams; Binayag Toro, 201.75 grams; Americano, 111.97 grams; Pakil Black Purple, 103.19 grams; Short Sinanpiro, 100.76 grams; and Small Native Purple, 35.38 grams. The Los Baños Black Purple which served as control or check variety produced 161.08 grams.

4. In percentage of survival from the time of planting to the end of the experiment, the different varieties studied gave the following relative ratios: Americano, 89.13 per cent; Sinanpiro, 85.42 per cent; Short Sinanpiro, 69.30 per cent; Small Native Purple, 62.20 per cent; Los Baños Black Purple, 45.42 per cent; and Bina-

yag Toro, 43.50 per cent. The common pests found were *Caenocoris inermipes* Stal, and a leaf-hopper, unidentified. The most common diseases were: the blight caused by *Phyllosticta hortorum* Speg., and stem rot, by *Sclerotium rolfsii* Sacc.

5. The earliest flowering variety was Los Baños Black Purple which had its first flower bud on the average of 123 days from the time of planting. The latest flowering variety was Small Native Purple which had its first flower on the average of 142 days after planting.

6. The variety which had the heaviest fruits as vegetable was Binayag Toro which had an average of 77.48 grams; heaviest ripe fruits, Los Baños Black Purple which had an average of 106.20 grams.

7. According to seediness, the varieties which were seedy were Small Native Purple, 6.8 per cent; Binayag Toro, 6.61 per cent; Short Sinanpiro, 6.11 per cent; Americano, 5.72 per cent; Sinanpiro, 5.59 per cent; Pakil Black Purple, 4.71 per cent; and Los Baños Black Purple, 4.10 per cent.

8. The varieties classified according to toughness of fruits were: flabby—Los Baños Black Purple, Small Native Purple, Short Sinanpiro, Sinanpiro, and Pakil Black Purple; tough—Binayag Toro and Americano.

9. The different local varieties showed variations in the percentage of flower setting. Binayag Toro gave 83.33 per cent, and Pakil Black Purple and Americano, about 30 per cent.

10. Generally speaking, eggplant fruits may be harvested from five and one-half months to six months from the time of sowing. Drought tends to delay the time of harvesting.

11. After two cultures, Los Baños Black Purple, Sinanpiro, and Americano were selected for high resistance to pests and diseases, and for good eating quality.

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TABLE 1

Variability in agronomic characters of an eggplant variety. Los Baños Black Purple

AGRONOMIC CHARACTERS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
			per cent
Number of days a flower bud takes to appear from date of planting ...	68.0 ± 2.1	17.1 ± 1.5	25.25 ± 2.33
Number of days a fruit takes to reach maturity	45.0 ± 0.3	1.4 ± 0.2	3.14 ± 0.50
Height of plants (in cm.)	33.6 ± 1.5	9.9 ± 1.1	26.51 ± 3.49
Lateral expansion of plants (in cm.)	43.0 ± 2.8	16.4 ± 2.1	38.21 ± 5.35
Length of leaves (in cm.)	19.8 ± 0.3	2.8 ± 0.2	14.41 ± 0.98
Width of leaves (in cm.)	11.8 ± 0.2	2.3 ± 0.1	19.96 ± 1.54
Weight of fruit as vegetable (in gms.)	63.5 ± 2.7	16.4 ± 1.9	25.89 ± 3.29
Length of fruit as vegetable (in cm.)	14.6 ± 0.2	1.5 ± 0.1	10.47 ± 1.26
Diameter of fruit as vegetable (in cm.)	3.4 ± 0.1	0.2 ± 0.1	8.56 ± 1.02
Weight of ripe fruit (in gms.)	106.2 ± 7.2	32.2 ± 5.1	30.32 ± 5.04
Length of ripe fruit (in cm.)	14.9 ± 1.6	4.7 ± 0.7	31.89 ± 5.56
Widest diameter of ripe fruit (in cm.)	4.0 ± 0.1	0.4 ± 0.1	11.24 ± 1.81
Percentage of seeds (by weight) ..	4.1 ± 0.3	1.4 ± 0.2	34.72 ± 6.15

TABLE 1a

Variability in agronomic characters of an eggplant variety. Binayag Toro

AGRONOMIC CHARACTERS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
			per cent
Number of days a flower bud takes to appear from date of planting ...	72.3 ± 2.3	17.0 ± 1.6	23.59 ± 2.37
Number of days a fruit takes to reach maturity	41.0 ± 0.3	1.4 ± 0.2	3.14 ± 0.50
Height of plants (in cm.)	28.0 ± 0.9	5.1 ± 0.7	18.46 ± 2.68
Lateral expansion of plants (in cm.)	41.0 ± 3.5	18.9 ± 2.6	46.30 ± 7.62
Length of leaves (in cm.)	15.5 ± 0.2	2.2 ± 0.1	14.70 ± 1.08
Width of leaves (in cm.)	11.3 ± 0.2	2.1 ± 0.1	18.65 ± 1.38
Weight of fruit as vegetable (in gms.)	77.4 ± 1.5	9.1 ± 1.1	11.74 ± 1.47
Length of fruit as vegetable (in cm.)	6.8 ± 0.1	0.4 ± 0.1	5.94 ± 0.73
Widest diameter of fruit as vegetable (in cm.)	5.6 ± 0.1	0.7 ± 0.1	13.06 ± 1.08
Weight of ripe fruit (in gms.)	100.4 ± 4.9	23.2 ± 3.5	23.11 ± 3.67
Length of ripe fruit (in cm.)	7.2 ± 0.1	0.9 ± 0.1	12.52 ± 1.92
Widest diameter of ripe fruit (in cm.)	6.0 ± 0.9	0.4 ± 0.6	7.39 ± 1.11
Percentage of seeds (by weight) ..	6.6 ± 0.3	1.5 ± 0.2	23.86 ± 3.80

TABLE 1b

Variability in agronomic characters of an eggplant variety. Small Native Purple

AGRONOMIC CHARACTERS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
			per cent
Number of days a flower bud takes to appear from date of planting ...	87.3 ± 2.4	24.6 ± 1.7	28.23 ± 2.23
Number of days a fruit takes to reach maturity	37.3 ± 0.7	3.2 ± 0.5	8.56 ± 1.36
Height of plants (in cm.)	23.7 ± 0.7	5.2 ± 0.5	21.88 ± 2.28
Lateral expansion of plants (in cm.)	29.9 ± 1.3	9.6 ± 0.9	32.42 ± 2.55
Length of leaves (in cm.)	11.1 ± 0.1	1.7 ± 0.1	15.39 ± 0.75
Width of leaves (in cm.)	7.7 ± 0.1	1.4 ± 0.0	18.71 ± 0.92
Weight of fruit as vegetable (in gms.)	20.3 ± 1.3	5.9 ± 0.9	29.90 ± 5.16
Length of fruit as vegetable (in cm.)	11.4 ± 0.2	0.8 ± 0.1	7.68 ± 1.22
Widest diameter of fruit as vegetable (in cm.)	2.1 ± 0.1	0.4 ± 0.1	18.19 ± 2.99
Weight of ripe fruit (in gms.)	42.8 ± 1.4	6.6 ± 1.1	15.45 ± 2.47
Length of ripe fruit (in cm.)	11.9 ± 0.3	1.5 ± 0.2	13.04 ± 2.11
Widest diameter of ripe fruit (in cm.)	2.7 ± 0.1	0.1 ± 0.1	5.75 ± 0.91
Percentage of seeds (by weight) ..	6.8 ± 0.2	1.1 ± 0.1	16.36 ± 2.55

TABLE 1c

Variability in agronomic characters of an eggplant variety. Short Sinanpiro

AGRONOMIC CHARACTERS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
			per cent
Number of days a flower bud takes to appear from date of planting ...	82.9 ± 1.5	18.6 ± 1.1	22.42 ± 1.46
Number of days a fruit takes to reach maturity	39.7 ± 0.7	4.1 ± 0.5	10.43 ± 1.45
Height of plants (in cm.)	28.0 ± 1.0	9.2 ± 0.7	33.00 ± 2.82
Lateral expansion of plants (in cm.)	42.0 ± 1.9	18.1 ± 1.4	43.07 ± 3.88
Length of leaves (in cm.)	15.4 ± 0.1	1.7 ± 0.1	11.25 ± 0.54
Width of leaves (in cm.)	10.8 ± 0.1	1.4 ± 0.1	13.92 ± 0.88
Weight of fruit as vegetable (in gms.)	32.8 ± 1.2	9.1 ± 0.8	27.77 ± 2.84
Length of fruit as vegetable (in cm.)	11.9 ± 0.1	2.1 ± 0.1	16.36 ± 1.60
Widest diameter of fruit as vegetable (in cm.)	2.5 ± 0.1	0.2 ± 0.1	10.17 ± 0.99
Weight of ripe fruit (in gms.)	64.0 ± 0.6	5.2 ± 0.4	8.14 ± 0.69
Length of ripe fruit (in cm.)	14.6 ± 0.3	2.6 ± 0.2	18.26 ± 1.59
Widest diameter of ripe fruit (in cm.)	3.2 ± 0.1	0.2 ± 0.1	8.80 ± 0.74
Percentage of seeds (by weight) ..	6.1 ± 0.2	1.1 ± 0.1	18.75 ± 0.68

TABLE 1d

Variability in agronomic characters of an eggplant variety. Sinanpiro

AGRONOMIC CHARACTERS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
			per cent
Number of days a flower bud takes to appear from date of planting ...	76.1 ± 1.5	21.1 ± 1.1	27.74 ± 1.59
Number of days a fruit takes to reach maturity	39.6 ± 0.7	4.7 ± 0.5	11.88 ± 1.28
Height of plants (in cm.)	30.0 ± 1.0	11.0 ± 0.7	36.47 ± 2.64
Lateral expansion of plants (in cm.)	55.6 ± 2.4	23.2 ± 1.5	42.33 ± 3.17
Length of leaves (in cm.)	15.3 ± 0.1	2.4 ± 0.1	16.14 ± 0.79
Width of leaves (in cm.)	10.6 ± 0.1	2.0 ± 0.1	19.15 ± 0.97
Weight of fruit as vegetable (in gms.)	46.0 ± 1.0	11.1 ± 0.7	24.20 ± 1.69
Length of fruit as vegetable (in cm.)	14.7 ± 0.1	1.9 ± 0.1	13.49 ± 0.91
Widest diameter of fruit as vegetable (in cm.)	2.9 ± 0.1	0.2 ± 0.1	9.23 ± 0.61
Weight of ripe fruit (in gms.)	79.7 ± 1.7	23.6 ± 1.2	29.64 ± 1.64
Length of ripe fruit (in cm.)	16.5 ± 0.2	2.0 ± 0.1	18.25 ± 0.60
Widest diameter of ripe fruit (in cm.)	3.3 ± 0.0	0.3 ± 0.2	11.26 ± 0.60
Percentage of seeds (by weight) ..	5.5 ± 0.2	1.2 ± 0.1	21.59 ± 4.15

TABLE 1e

Variability in agronomic characters of an eggplant variety. Americano

AGRONOMIC CHARACTERS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
			per cent
Number of days a flower bud takes to appear from date of planting ...	81.9 ± 1.3	18.5 ± 0.9	22.59 ± 1.21
Number of days a fruit takes to reach maturity	40.8 ± 0.6	3.6 ± 0.4	8.93 ± 1.06
Height of plants (in cm.)	36.9 ± 0.7	8.3 ± 0.5	22.61 ± 1.53
Lateral expansion of plants (in cm.)	52.0 ± 1.5	16.9 ± 1.0	32.52 ± 2.30
Length of leaves (in cm.)	16.1 ± 0.1	2.1 ± 0.1	13.06 ± 0.63
Width of leaves (in cm.)	11.3 ± 0.1	1.8 ± 0.0	16.44 ± 0.73
Weight of fruit as vegetable (in gms.)	61.3 ± 1.7	18.4 ± 1.2	30.06 ± 4.27
Length of fruit as vegetable (in cm.)	9.4 ± 0.1	1.6 ± 0.1	17.91 ± 1.23
Widest diameter of fruit as vegetable (in cm.)	3.9 ± 0.1	0.5 ± 0.1	12.49 ± 0.86
Weight of ripe fruit (in gms.)	79.9 ± 2.6	25.9 ± 1.8	32.38 ± 2.59
Length of ripe fruit (in cm.)	9.5 ± 0.1	1.8 ± 0.1	19.51 ± 1.47
Widest diameter of ripe fruit (in cm.)	4.4 ± 0.0	0.5 ± 0.0	11.49 ± 0.85
Percentage of seeds (by weight) ..	5.7 ± 0.2	1.2 ± 0.1	21.88 ± 3.16

TABLE 1f

Variability in agronomic characters of an eggplant variety. Pakil Black Purple

AGRONOMIC CHARACTERS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
			per cent
Number of days a flower bud takes to appear from date of planting	78.2 ± 1.7	23.1 ± 1.2	29.68 ± 1.73
Number of days a fruit takes to reach maturity	42.7 ± 0.5	3.7 ± 0.5	8.65 ± 1.19
Height of plants (in cm.)	41.1 ± 0.9	10.4 ± 0.7	25.28 ± 1.89
Lateral expansion of plants (in cm.)	54.4 ± 2.0	20.8 ± 1.4	38.33 ± 3.06
Length of leaves (in cm.)	16.6 ± 0.1	2.3 ± 0.1	14.04 ± 0.68
Width of leaves (in cm.)	11.1 ± 0.1	1.8 ± 0.0	16.24 ± 0.79
Weight of fruit as vegetable (in gms.)	52.6 ± 1.9	18.8 ± 1.3	35.89 ± 2.97
Length of fruit as vegetable (in cm.)	15.3 ± 0.2	2.5 ± 0.1	16.83 ± 1.26
Widest diameter of fruit as vegetable (in cm.)	3.2 ± 0.0	0.4 ± 0.0	12.72 ± 0.94
Weight of ripe fruit (in gms.)	90.1 ± 3.9	34.8 ± 2.8	38.68 ± 3.55
Length of ripe fruit (in cm.)	16.5 ± 0.5	4.5 ± 0.3	27.75 ± 2.40
Widest diameter of ripe fruit (in cm.)	3.7 ± 0.0	0.5 ± 0.0	16.24 ± 1.37
Percentage of seeds (by weight) ..	4.7 ± 0.1	0.7 ± 0.1	2.40 ± 0.38

TABLE 2

Observations on the first flower and first fruit of seven local eggplant varieties

VARIETY NAME	NO. OF BUDS OBSERVED	NO. OF BUDS OPENING	NO. OF FLOWERS SETTING	PER CENT OF BUDS OPENING [a]	NO. OF FRUITS MATURING	PER CENT OF FLOWERS SETTING [b]	PER CENT OF FRUITS MATURING [c]
Los Baños Black Purple (Standard)	30	26	18	86.67	5	79.23	27.78
Binayag Toro	29	24	20	82.75	4	83.33	20.00
Small Native Purple .	46	39	25	84.78	4	64.10	16.00
Short Sinanpiro	60	56	42	93.33	12	75.00	28.57
Sinanpiro	76	73	45	96.05	20	61.64	44.44
Americano	84	78	23	91.89	9	29.50	39.13
Pakil Black Purple ..	74	68	21	67.65	4	30.88	19.05

[a] Per cent of flowers opening $= \dfrac{\text{Number of buds opening}}{\text{Number of buds observed}}$

[b] Per cent of flowers setting $= \dfrac{\text{Number of flowers setting into fruits}}{\text{Number of buds opening}}$

[c] Per cent of fruit maturing $= \dfrac{\text{Number of fruits maturing}}{\text{Number of flowers setting into fruits}}$

A STUDY OF CERTAIN PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOME MAQUILING SOILS [1]

ISAAC J. ARISTORENAS

A large part of the agricultural soils around Mount Maquiling has been surveyed and classified into soil series and types. Samples collected have been analyzed chemically and physically. But there has been no attempt to compare in one study soils from all the different localities about Mount Maquiling, at least not to the degree attempted in the present work.

The present soil study is an attempt to compare a large number of soils physically, according to the Keen-Raczkowski "box" experiment (1921), and chemically as to their reaction expressed in pH values and their potash content. In addition, a very intensive study was made of the soil of a previously unmapped portion of the Maquiling area, particularly the experimental lowland rice field of the Economic Garden.

Objects of the present work

The objects of the present work were: (*a*) to determine certain physical and chemical characteristics of soils of the Maquiling area; (*b*) if possible, to learn the reason or reasons for the unusual infertility of the Economic Garden rice plots. The physical and chemical characteristics of soils are:

(1) The hydrogen-ion concentration of soils
(2) Apparent and real specific gravities, maximum water-holding capacity, pore space, and volume expansion by the Keen-Raczkowski "box" experiment
(3) Potassium content of soils by the colorimetric method

Time and place of the work

This work was begun in August, 1934, and closed on May 4, 1935. The laboratory portion of the work was performed in the Department of Soils, College of Agriculture. The field work was

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in the area between the Bureau of Public Works' quarry and the Manila Railroad line, east of the Naval Radio Station. This area is a portion of the economic garden of the Bureau of Plant Industry.

MATERIALS AND METHODS

Soil samples used. Soil samples collected by the writer from a portion of the Economic Garden, Los Baños, Laguna, and soil samples already collected and stored in the Department of Soils were used in the study. These samples are listed in tables 1a and 1b.

Preparation of soil samples. The preparation of the different soil samples was carried out in the approved manner.

Physical determinations. The determinations of the apparent and real specific gravities, maximum water-holding capacity, pore space, and volume expansion of the various soil samples were determined by following the method and technique prescribed by Keen and Raczkowski (1921) and Coutts (1930). The only modification made was a device which removed the soil particles that were in between the brass box walls. The box with the fitted filter paper was weighed. Then the box was immersed in water for a moment to saturate the filter paper. The box having been wiped dry, it was again weighed. The box and its filter paper were then dried, after which the box was filled with air-dry soil by the use of the compacting machine. For compacting the soil in the box, the writer used five minutes for each box with approximately 100 revolutions of the crank per minute. When the box was nearly full and contained sufficient soil to be struck flat with a spatula the lower edge of the box was tapped with the spatula and more soil was added. The tapping and addition of soil were repeated until no further settling occurred; the time was exactly five minutes. Finally the soil was struck flat with the spatula. Then, by using some rubber tubing with a glass-tipped jet, any spilled soil was blown out from between the walls of the box and the vertical edges of the bottom, after which the box and contents were weighed. Then the filled box was placed in a shallow dish containing water and left overnight. From time to time, additional water was added to the dish to keep its level as nearly constant as practicable. The next morning the box was removed from the water, wiped dry, and weighed. The soil which had expanded above the top of the box was then removed with a sharp-edged, straight blade moved across the box horizontally. The surplus soil was placed in a tared evaporating dish and weighed in the analytical balance. Any soil adhering to the lower portion of the blade was

replaced in the box. After that the box containing the wet soil was also weighed on the Cenco balance. Then the box and the evaporating dish and contents were placed in the oven for twenty-four hours, subjecting them to a temperature of between 100 and 105°C. After oven-drying, the box containing the residual soil and evaporating dish containing the surplus soil were cooled and weighed. In addition, the internal volume of the box was determined and also the moisture present in the air-dry soil used in the experiment. It was found that subjecting the saturated soil in the oven for twenty-four hours at 100 to 105°C. is sufficient to give a "constant weight" within the required limits.

The data on weighings and measurements were the following:

a — weight of brass box + filter paper
b — weight of brass box + saturated filter paper
c — a + air-dry soil
d — b + saturated soil sample
e — b + saturated residual soil sample
f — a + oven-dry residual soil sample
g — weight of evaporated dish alone
h — g + saturated surplus soil
i — g + oven-dry surplus soil
v — internal volume of brass box

From the data given above the following "single value" constants are obtained:

(1) $$\frac{c - a}{v} = \text{weight of 1 ml. of soil (apparent specific gravity)}$$

(2) $$\frac{(f - a)}{v - (c - f) + (h - a)} = \text{real specific gravity}$$

(3) $$\frac{(d - b) - (c - a)}{c - b} = \text{amount of water taken up by 1 gram of soil}$$

Note: Correct $(c - a)$ for X per cent moisture in the air-dry soil sample.

(4) $$\frac{(e - b) - (f - a)}{v} = \text{pore space}$$

(5) $$\frac{(h - i) + (i - g)\text{ sp. gr.}}{v} = \text{volume expansion of 1 gm. soil}$$

The pH determination. For the determination of the hydrogen-ion concentration (pH values) of the soils the quinhydrone electrode

was used, following closely the method employed by E. H. Sargent & Co. The formula used for the determination of pH was:

$$\frac{0.4538 + E}{0.06} = pH$$

The correction factor was pH –0.19.

Potassium determination. For the colorimetric determination of potassium (K_2O), the microchemical method of Steenkamp (1934) was used. Since Steenkamp did not specify the amount of extracting solution, the use of 100 ml. of the extracting solution (25/500 HCl) for every 20 grams of soil was employed from which about 80 ml. extract was collected. Whatman No. 42 filter paper was used instead of the hardened filter paper.

For the computation of the amount of K_2O contained in the unknown, the following formula was used:

$$X = \frac{YR}{U} \times \text{aliquot}$$

$$\text{Per cent of } K_2O = \frac{\text{milligrams } K_2O}{1000 \times \text{wt. of sample} - \text{wt. of moisture}} \times 100$$

Wherein:
- X = milligrams of K_2O in unknown
- Y = milligrams of K_2O in known standard
- R = reading of standard
- U = reading of the unknown

The dilution factor in this case is 80/20.

RESULTS

Results of this investigation are presented in tables which are on file in the Department of Soils.

The averages of various determinations made on the different soil types and the different soil series are shown in table 2.

DISCUSSION OF RESULTS

Physical characteristics of the different soil types and series

In this study, apparent and real specific gravities, maximum water-holding capacity, pore space, and volume expansion of soils were determined by the Keen-Raczkowski "box" experiment. According to Hardy (1925), Keen (1931), Keen and Raczkowski

(1921), and Komkris [2], these different determinations are governed by the colloid and clay content and by the amount of organic matter (humus) present in the soil. The more the colloid, clay, and humus content the higher the values for the maximum water-holding capacity, pore space, and volume expansion, whereas the real and apparent specific gravities vary.

The Nanhaya clay exhibited the highest values for the maximum water-holding capacity, pore space, and volume expansion. The reason why the last five soil types behaved differently from the rest is that the subsoils of these types are not completely weathered; therefore, weight for weight, the surface soil would have a high clay content and organic matter. Thus the figures for these five soil types are lower than for any of the other types because these are low in humus-clay content. As regards apparent and real specific gravities, the values vary considerably within each soil type with the general tendency for the subsoils to show higher values than the surface soil.

In general, the five different values found by using the Keen-Raczkowski method vary considerably among the soil samples in the same soil type and also among soil types in a series and of different soil series.

Among the soil series the Ibaan series exhibits the highest apparent and real specific gravities for both surface and subsurface soils. This is due to the fact that this series has not undergone as great a degree of weathering and disintegration as the other series; the Calumpang series has comparatively the lowest values, as the subsoil has recently been exposed by erosion.

Chemical characteristics of the different soil types and series

Among the different soil series for the surface soil the Lipa series has the highest percentage of potassium, 0.11 per cent, while Nanhaya series has the lowest, 0.02 per cent. For the subsoil, Ibaan series has 0.07 per cent, whereas Lipa and Nanhaya series have only 0.03 per cent.

From the comparisons made in this study, there is nothing notable shown regarding the Economic Garden rice plots which would explain their marked infertility.

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[2] KOMKRIS, THUAN. A study of "single value" soil properties, moisture relationships, loss on ignition, sticky point and amount of clay. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1933. Unpublished.)

However, Talento [3] worked on soils of the hot-spring portion of the Economic Garden rice plots to determine the adaptability of this area for growing rice. He found that the soils did not require lime but recommended the application of 5-2.5-2.5 fertilizer, using ammonium sulfate, double superphosphate, and sulfate of potash. But inasmuch as subsequently the soil in the Economic Garden rice plots has been disturbed, Talento's recommendations would probably not now apply because of chemical and physical changes in the soil.

SUMMARY AND CONCLUSIONS

The physical characteristics of the soils studied may be summarized as follows:

1. Apparent and real specific gravities vary considerably among the different soil types.

2. The values for the maximum water-holding capacity, pore space, and volume expansion vary in different soil types.

3. A soil type may be high in maximum water-holding capacity but significantly low in pore space. Macolod clay loam sloping phase behaves in this way.

4. Generally, in an unweathered subsoil with surface soil which is alluviated considerably, the values for apparent and real specific gravities are high, and conversely the maximum water-holding capacity, pore space, and volume expansion are lower than the surface soil.

5. The different soil types as well as the different soil series exhibit different ranges of variations for each of the five "single value" constants, namely, apparent specific gravity, real specific gravity, maximum water-holding capacity, pore space, and volume expansion.

The chemical characteristics may be summarized as follows:

1. All the soil samples used in this study have a slightly basic reaction.

2. There seems to be no marked difference between the surface soil and the subsoil as to their reaction. Also, there is no relationship observed between pH of the soil and its fertility nor between pH and depth.

3. In the case of the soils studied, hydrogen-ion concentration of soil can not be used as a criterion for soil type classification, as it is inconclusive with such slight variations.

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[3] TALENTO, APOLINAR. Tests of soils from the hot spring regions of Los Baños for growing rice in pot culture. Thesis presented for graduation witn the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1923. Unpublished.)

4. "Available" potassium is always present in the soil studied though in varying quantities. Generally, there is more "available" potassium in the surface soil than in the subsoil.

5. The "available" potassium content within the samples of any one type varies so widely that potassium content of the soils studied could not be used either for soil type or for soil series identification.

6. There is no definite relationship between the hydrogen-ion concentration of any type of soil and its "available" potassium content.

Inasmuch as the data obtained in this study are not conclusive to the point of giving recommendation, a further and intensive study of Maquiling area soils should be encouraged.

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TABLE 1a

Soil samples used in the present study with their numbers, series, and types

SAMPLE NUMBER	ORIGINAL SAMPLE NUMBER	SOIL SERIES	SOIL TYPES AND PHASES	HORIZON
1	21–a	Los Baños	CL deep	surface
2	21–b	do	do	subsoil
3	21–1	do	do	surface
4	21–2	do	do	subsoil
5	22–1	do	do	surface
6	22–2	do	do	subsoil
7	8–a	do	do	surface
8	8–b	do	do	subsoil
9	16–a	do	do	surface
10	16–b	do	do	subsoil
11	23–1	do	do	surface
12	23–2	do	do	subsoil
13	24–1	do	do	surface
14	24–2	do	do	subsoil
15	25–1	do	do	surface
16	25–2	do	do	subsoil
17	26–1	do	do	surface
18	26–2	do	do	subsoil
19	23–a	do	CL med. slop	surface
20	23–b	do	do	subsoil
21	4–1	do	do	surface
22	4–2	do	do	subsoil
23	3–1	do	do	surface
24	3–2	do	do	subsoil
25	18–1	do	do	surface
26	18–2	do	do	subsoil
27	6–	do	do	surface
28	6–a	do	do	subsoil
29	11–	do	do	surface
30	11–a	do	do	subsoil
31	2–a	do	CL Med. Steep	surface
32	2–b	do	do	subsoil
33	10–1	do	do	surface
34	10–2	do	do	subsoil
35	16–1	do	do	surface
36	16–2	do	do	subsoil
37	6–a	do	CL Shallow	surface
38	6–b	do	do	subsoil
39	18–1	do	do	surface
40	18–2	do	do	subsoil
41	4–1	do	do	surface
42	4–2	do	do	subsoil
43	11–1	do	do	surface
44	11–2	do	do	subsoil
45	18–a	Macolod	CL Sloping	surface
46	18–b	do	do	subsoil
47	13–1	do	do	surface
48	13–2	do	do	subsoil
49	28–1	do	do	surface
50	28–2	do	do	subsoil
51	12–a	do	CL Steep	surface
52	12–b	do	do	subsoil

TABLE 1a (continued)

Soil samples used in the present study with their numbers, series, and types

SAMPLE NUMBER	ORIGINAL SAMPLE NUMBER	SOIL SERIES	SOIL TYPES AND PHASES	HORIZON
53	(5, 6, 7)1	Lipa	Si CL	surface
54	(5, 6, 7)2	do	do	subsoil
55	3–1	do	CL deep	surface
56	3–2	do	do	subsoil
57	20–1	do	do	surface
58	20–2	do	do	subsoil
59	2–1	do	do	surface
60	2–2	do	do	subsoil
61	2–1	do	CL Medium	surface
62	2–2	do	do	subsoil
63	17–1	do	do	surface
64	17–2	do	do	subsoil
65	6–1	do	do	surface
66	6–2	do	do	subsoil
67	15–1	do	CL Shallow	surface
68	15–2	do	do	subsoil
69	2–a	do	CL	surface
70	2–b	do	do	subsoil
71	6–a	do	do	surface
72	6–b	do	do	subsoil
73	10–a	do	do	surface
74	10–b	do	do	subsoil
75	13–1	do	L deep	surface
76	13–2	do	do	subsoil
77	8–1	Ibaan	CL Shallow	surface
78	8–2	do	do	subsoil
79	11–1	Calumpang	CL	surface
80	11–2	do	do	subsoil
81	12–1	do	L deep	surface
82	12–2	do	do	subsoil
83	10–1	do	do	surface
84	10–2	do	do	subsoil
85	23–1	Nanhaya	C	surface
86	23–2	do	do	subsoil

TABLE 1b

Soil samples used in the present study with their numbers, series, types, and depths

SAMPLE NUMBER	ORIGINAL SAMPLE NUMBER	SOIL SERIES	SOIL TYPES AND PHASES	HORIZON	DEPTH
					cm.
87	1a–1	Calumpang	SiL	surface	0–10
88	1a–2	do	CL	subsurface	10–25
89	1–b	do	do	subsoil	25–90
90	2a–1	do	SiL	surface	0–10
91	2a–2	do	CL	subsurface	10–20
92	3–a	do	do	subsoil	20–80
93	2–b	do	SiL	surface	0–20
94	3–b	do	CL	subsoil	20–65
95	4a–1	do	SiL	surface	0–5
96	4a–2	do	CL	subsurface	5–15
97	4–b	do	do	subsoil	15–55
98	5a–1	do	VFi SyL	surface	0–10
99	5a–2	do	CL	subsurface	10–25
100	5–b	do	do	subsoil	25–85
101	6a–1	do	VFi SyL	surface	0–20
102	6a–2	do	CL	subsurface	20–30
103	6–b	do	do	subsoil	30–90
104	7–a	do	VFi SyL	surface	0–20
105	7–b	do	CL	subsoil	20–70
106	8a–1	do	SyL	surface	0–10
107	8a–2	do	CL	subsurface	10–30
108	8–b	do	do	subsoil	30–65
109	9–a	do	GrSyL	surface	0–45
110	9–b	do	CL	subsoil	45–95
111	10a–1	do	SyL	surface	0–20
112	10a–2	do	CL	subsurface	20–35
113	10–b	do	do	subsoil	35–70
114	11a–1	do	SiL	surface	0–10
115	11a–2	do	CL	subsurface	10–45
116	11–b	do	do	subsoil	45–99
117	12–a	do	C	surface	0–5
118	12b–1	do	do	subsoil	5–30
119	12b–2	do	do	subsoil	30–90
120	13–a	do	do	surface	0–20
121	13b–1	do	do	subsoil	20–35
122	13b–2	do	do	subsoil	35–90
123	14–a	do	do	surface	0–15
124	14–b	do	do	subsoil	15–95
125	15–a	do	do	surface	0–25
126	15–b	do	do	subsoil	25–95
127	16	do	do	surface	

TABLE 2

Averages of the seven determinations obtained in every soil series

SOIL SERIES	HORIZON	APPARENT SPECIFIC GRAVITY	REAL SPECIFIC GRAVITY	MAX. WATER HOLDING CAPACITY OF 1 GRAM OF SOIL	PORE SPACE IN 1 GRAM OF SOIL	VOLUME EXPANSION OF 1 GRAM OF SOIL	pH	K_2O
								per cent
Los Baños	surface soil	1.21	1.27	0.62	0.61	0.26	7.38	0.06
	subsoil	1.22	1.32	0.68	0.64	0.32	7.37	0.05
Macolod	surface soil	1.14	1.18	0.70	0.61	0.24	7.38	0.08
	subsoil	1.25	1.37	0.72	0.63	0.32	7.38	0.05
Lipa	surface soil	1.23	1.28	0.55	0.57	0.15	7.37	0.11
	subsoil	1.27	1.43	0.64	0.63	0.34	7.37	0.03
Ibaan	surface soil	1.32	1.37	0.50	0.59	0.19	7.39	0.05
	subsoil	1.33	1.52	0.57	0.65	0.34	7.37	0.07
Nanhaya	surface soil	1.27	1.38	0.66	0.67	0.31	7.40	0.02
	subsoil	1.29	1.40	0.69	0.66	0.41	7.40	0.03
Calumpang	surface soil	1.14	1.16	0.65	0.59	0.25	7.35	0.05
	subsoil	1.11	1.16	0.65	0.59	0.22	7.38	0.05

A REVIEW: INTRODUCTION TO AGRICULTURAL ECONOMICS IN THE PHILIPPINES [1, 2]

This is the first book on the subject that has appeared in the Philippines and for that alone, if for no other reason, Mr. Maulit deserves the highest praise. The work is certainly a tribute to his industry and skill. The book, as the Director of Education states in the foreword, is "intended primarily for students in agricultural and rural high schools" although it is further his "hope that it will also be helpful to those who are now actually engaged in agricultural production." The author's views on agricultural economics as a course of study is forcefully stated in his suggestions to teachers as follows: "The importance of teaching the subject in terms of the actual, concrete, and practical can never be overemphasized in the Philippines" and he says further that "the text has been prepared with reference to Philippine conditions."

But the dearth of data on the various aspects of agricultural economics in the Philippines has obviously prevented the author from fully realizing his praiseworthy objectives. As a result, he contents himself in stating general principles, notably in his chapters on Land and Agriculture and on Prices of Farm Products (pp. 180-183). With great skill, the author develops the various aspects of farm management in one chapter (Chapter V) covering nearly one-third of the entire book by drawing heavily from principles developed by eminent extra-Philippine farm management workers like Boss and Warren. It is regrettable, however, that these discussions are sadly barren of results of investigations on Philippine conditions of farm organization and management.

There are a few errors in principles of economics which have crept in the book, briefly, as follows:

(1) The illustration of the law of diminishing utility (p. 61). The spread of purchases of a good over a period of one week violates a fundamental assumption of a "given time" of the principle.

(2) A statement (p. 55) "that a lowering of the standard of living among agricultural laborers may result in a reduction of the

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[1] General contribution No. 572.

[2] MAULIT, DIMAS. 1936. Introduction to agricultural economics in the Philippines. 317 p. Manila: Bureau of Printing.

cost of local agricultural production" implies advocacy by the author of this method, in view of his additional statement on the same page that high wages are an explanation of our comparatively high cost of production. This is an erroneous belief with which no economist can agree. High wages do not necessarily mean high cost. A high standard of living means often a high level of efficiency so that high wages usually result in low and not high cost. This is an accepted economic principle. It is a departure from what is correct thinking in economics to suggest a reduction of the laborer's standard of living in an effort to achieve low cost.

(3) The author confuses the two terms, money and credit, in his discussions of banking (p. 65). Commercial banks today do not necessarily lend money entrusted to them by savers (he calls them depositors) of capital. Most of the deposits today are "created deposits" which arise from the loan and discount operations of banks, and banks loan their credit and not their funds.

(4) Government price fixing (p. 182) does not always mean stabilizing price at a lower level to protect consumers as one would infer from the author's statement. It may also stabilize price at a higher level to insure a profitable price to producers.

There are also a few errors of fact regarding certain points as follows:

(1) Brazil's efforts to regulate coffee prices are not "recent" for, as a matter of fact, it is one of the earliest attempts; it began in 1906.

(2) Under Act 3895 (p. 69) only six, and not ten, credit associations were actually organized.

(3) The author confuses the corporation law, Act 1459, with the coöperative marketing law, Act 3425 (pp. 194 and 238). The minimum payment on subscription for coöperative marketing associations is 20 per cent, and not 25 per cent.

(4) The writer, in making references to the Cuban preferential (p. 212) of 20 per cent as regards her trade with the United States, is apparently unaware of a trade agreement (effective September, 1934) which gives Cuba further concessions. For instance, the Cuban rate for sugar was reduced from 1.5 cents per pound, which was the previous preferential rate at 20 per cent, to 0.9 cent per pound.

These imperfections, however, are minor for on the whole the book has much useful material to commend itself to students and teachers of agriculture. After reading the book, one can not help

but admire the author for his pioneer effort at writing on agricultural economics. Agricultural economics is new in the Philippines and a book of this kind will do much to focus attention upon a hitherto neglected field of study. While it is true that there is a dearth of data on agricultural economics in this country, it is all the more regrettable that what little there is available in the College of Agriculture and the Bureau of Plant Industry has not been fully utilized by the author. His chapters on farm records, cost of production, capital and credit, land and agriculture, marketing farm products, and rural life and coöperation would have been enriched with some Philippine material, which is his main objective, had he taken pains to examine the results of several investigations on these subjects by the two foregoing institutions.

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Of the Department of Agricultural Economics

COLLEGE AND ALUMNI NOTES

Loyalty Day, October 10, was observed this year with Major General Paulino Santos, chief of staff of the Philippine Army, as the guest of honor. A number of old alumni and former faculty members of the College attended the celebration.

Mr. Antonino Buenaventura, of the Conservatory of Music, is the author of a new tune for "Hail College Dear", the College of Agriculture song, which was sung publicly for the first time at the program held at Baker Memorial Hall on Loyalty Day, with the composer himself conducting.

George Bernard Shaw's "Arms and the Man" was presented at the Baker Memorial Hall in the evening of October 9, under the auspices of the Music and Drama Committee of the College. The cast included Misses Salud Quiatson, Socorro Olalde, and Virginia Mondoñedo, and Messrs. Anuporn Kridakara, Antonio Ocampo, José Velasco, Dioscoro Umali, and Virgilio Celis. Mrs. Ruth McCullough Mack, assistant professor of English, directed the play.

Judge John W. Haussermann was the donor of the beautiful velvet curtains which now hang on the stage of the Baker Memorial Hall.

Hon. J. Weldon Jones, financial adviser to the American High Commissioner, was the guest of honor at the meeting of the SAR (Society for the Advancement of Research) on September 30, on

the occasion of the initiation to associate membership of Messrs. Remberto Z. Ver and Lorenzo P. Zialcita, Jr., senior students at the College of Agriculture.

The following papers were read at the meeting of the Los Baños Biological Club on September 23:

Dr. F. M. Fronda and Mr. Engracio Basio. Ducks in battery laying cages.

Mr. Justino Seguerra. The solid wood content of stacked ipil-ipil firewood and its heating value.

Dr. N. B. Mendiola. Propagation under cultivation of wild plants under Act 3893.

A tea was given by the faculties of the College of Agriculture and the School of Forestry on October 10 at the Seniors' Social Garden in honor of their Manila colleagues of the University of the Philippines. Special features included the exhibition of Filipino folk dances by University students from Manila against a realistic setting of typical native gardens built by the Department of Agronomy.

The following faculty members were high school convocation speakers:

August 20. Nueva Ecija High School. Dr. F. M. Fronda.

October 1. Tayabas High School. Dr. L. B. Uichanco (University of the Philippines sponsorship).

October 4. Laguna High School. Dean B. M. Gonzalez (World Day for Animals).

Dr. E. Stanley Jones, the well-known traveller and lecturer, spoke at a convocation in the auditorium of the College of Agriculture on October 27.

Recent visitors on the campus included Messrs. Sozo Inamura and Taketomi Kamakura, pathologists of the Bureau of Protective Industries, Taiwan, Formosa, and Mr. M. Isaji, of the Ohta Development Co., on September 10, and Messrs. William A. Lloyd and Owen Dawson, technical advisers to the Joint Preparatory Committee, on September 15.

Mr. L. M. Thuan Komkris, '34, has been appointed by his government, chief of the South Siam Agricultural Experiment Station at Haadyai.

Eliseo T. Gomez, '25, was recently granted the degree of doctor of philosophy by the University of Missouri. His dissertation on a phase of dairy bacteriology appeared as a research bulletin of the Missouri Agricultural Experiment Station.

THE PROPOSED MERGER IN PHILIPPINE AGRICULTURAL RESEARCH AGENCIES

There has been of late a proposal originating from responsible quarters in Manila to consolidate various research agencies of the Philippine government into a National Agricultural Experiment Station, to be located in the College of Agriculture. The units involved in this plan, in addition to this College, are to be primarily the Bureau of Plant Industry and to some extent also the Bureaus of Animal Industry and of Forestry, of the Department of Agriculture and Commerce. According to the preliminary plan, all fundamental researches in agriculture are to be conducted by the National Agricultural Experiment Station. Such personnel of the bureaus as may be needed from time to time are to be assigned to this Station for conducting particular lines of investigation. The regional stations now operating under the bureaus are to have as their principal functions the conducting of field or factory tests to determine adaptability to local conditions of live stock or plant strains or of well-known methods.

The immediate motive behind the proposed realignment is unfortunately economic. It is believed that waste will thereby be minimized, if not eliminated, through avoidance of needless duplication. One is reminded on this point of a biographical serial on an outstanding automobile manufacturer, Mr. Walter P. Chrysler, which appeared in recent issues of an American weekly magazine, wherein the statement was attributed to him that during the worst days of the depression, when he had to practise retrenchment, there was one branch in his establishment that he not only did not curtail but which he strengthened. This branch was his research department. He was an uncompromising believer in research as the only way out of the then existing business embarrassment and later events have proved the wisdom of his policy.

Financial considerations aside, however, the contemplated change touches upon a fundamental question, the answer to which might well have been sought since the initial launching of our various governmental units that have been charged with the duty of agricultural promotion. Of course, friendly competition has a wholesome

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influence on any undertaking. It is elementary knowledge that anti-trust laws were enacted as a check to corporations which have a disquieting way of growing so powerful that they swallow up rival concerns and form a huge business conspiracy against the best interests of the public. But the analogy certainly can not be extended to scientific work in the Philippines, especially to research activities in agriculture. Because of its novelty in this country, agricultural research suffers from lack of men. With rare exceptions, nearly the entire supply of the government's technical personnel in agriculture has been drawn from among the alumni of this College, which, from its establishment in June, 1909, to June, 1937, has graduated only 1,111. This number includes 20 foreigners, 16 of them from the kingdom of Siam, who entered the service of their respective governments after obtaining their degrees. Obviously, not all agricultural graduates from this or from any other college could be expected to develop into researchers. Indeed, we consider ourselves fortunate that among our alumni, about 0.6 per cent, or a trifle over 1 out of 200, have demonstrated to a greater or lesser degree a sustained interest and capacity for scientific inquiry. As attested in part by their standing as members of the National Research Council of the Philippine Islands and of other discerning scientific organizations here and abroad, most of the ranking agricultural researchers in the Philippines are on the faculty roll of the College of Agriculture. Another, though, of course, subordinate gauge, is the fact that nearly 80 per cent of the Filipino agricultural researchers that have received the benefit of advanced training, as shown by their doctorates from American (including one European) universities, are in this College. Academic degrees, however, are known to be of varying reliability as a measure of usefulness in research. To some persons a doctor's degree may even be a spiritual allergent. For one thing, the performance records of all faculty members of the College of Agriculture are carefully compiled and published every year, and from these contribution lists the impartial critic may draw his own conclusions.

That the College of Agriculture should have been singled out as the prospective site for the National Agricultural Experiment Station is assuredly more than an accident. This College has been actually functioning as an experiment station for twenty-eight years. Agricultural research has been its paramount obligation largely by force of necessity from the time it opened its doors to students. Because of lack of data on Philippine agriculture, data have had to be

secured in order that instruction can be carried on. One vainly wished he could share for Philippine agriculture in the jubilant optimism of Emerson about nineteenth-century America: "Our day of dependence, our long apprenticeship to the learning of other lands, draws to a close." The "uses of adversity" may not always have been "sweet," as Shakespeare puts it; but, despite lack of men and facilities, adversity has meant for the College to date a total output of 1,201 published scientific papers, in part from the pens of faculty members, and in part from those of thesis students under the direction of faculty advisers. This number does not include the 573 popular or semi-popular articles on subjects related to agriculture.

The close teamwork between faculty and students can not but be conducive, in the free atmosphere of a university, to a robust vitality in research. The former brings to the work the safe conservatism of Daedalus which comes from maturity and broader experience; the latter, the unfettered enthusiasm and recklessness of the youth in Icarus. There is, moreover, not that feeling of prompting from some tyrannical task-master whereby the workers, their initiative killed, soon give occasion to Gibbon's complaint that they "well remembered that they had a salary to receive, and only forgot that they had a duty to perform". Duty in this College, for that matter, has hardly been looked upon as duty, but as a pleasant adventure in the chase for some undiscovered truth. Where no call is made to bend efforts to a banal search for evidence that would justify some official policy or substantiate a superior's expressed views, the scientific investigator is satisfied that he is engaged in creative labor. It is only in such unregimented surroundings that the worker may find the joy of working and where he can be in a mood to reflect with Wordsworth:

> "To every natural form, rock, fruit, or flower,
> Even the loose stones that cover the highway,
> I gave a moral life: I saw them feel,
> Or linked them to some feeling: the great mass
> Lay bedded in some quickening soul, and all
> That I beheld respired with inward meaning."

The proposed establishment of the National Agricultural Experiment Station is in a sense a noble gesture on the part of the powers that be to set aright an ironic anomaly. A sizable bulk of the more fundamental scientific data and material currently in use in carrying out the Philippine government's agricultural program bears the telltale mark of College of Agriculture parentage. Yet, up to the present

time, the parent has been technically an outsider, a kibitzer, in this agricultural program. The new scheme, however, is not altogether in the nature of an unmixed blessing. The danger of surrendering a free research atmosphere, when inflexible, systematized budgets limit the lines of investigation along specifically charted routes, observance of standard working hours by the punch-clock, and, worst of all, executive dictation from some lay superior, might in the end make for a made-to-measure fitting into a preconceived bed of Procrustes of all scientific agricultural activities in this College. These misgivings may perhaps be unnecessarily pessimistic. It is quite certain that the College is strong enough to overcome the temporary shock of its first encounter with the new arrangement. Moreover, to paraphrase the late great president of Harvard University, Dr. Charles W. Eliot, for the College of Agriculture to receive support, it must deserve the support.

To prove that thorns are modified branches: Flacourtia ramontchi l'Hérit.

PHYSIOLOGICAL STUDIES ON POULTRY: I. BODY MEASUREMENTS OF MALE AND FEMALE LOS BAÑOS CANTONESE FOWLS [1]

F. M. FRONDA AND ALFONSO S. MARCELO

WITH TWO TEXT FIGURES

As the Cantonese fowl is undeniably the most popular, and probably the most important economically, of all the breeds of poultry now raised in the Philippines, data on the average body measurements of this breed should be of some help as a guide in improving the qualities of Los Baños Cantonese chickens as egg producers. Rice, Hall, and Marble (1930) state that the body type of a fowl may be used as an indication of laying capacity, constitutional vigor, and sex dominance. As no studies along these lines have been made on the Los Baños Cantonese fowl, the present work was undertaken. The findings may aid in fostering the usefulness of the breed, and incidentally, they may furnish a guide to those who may want to take up other physiological studies on poultry.

These studies were made in the poultry laboratory of the Department of Animal Husbandry, College of Agriculture, Los Baños. The observations made form the first part of a series of physiological studies on poultry started in April, 1932, and closed in November, 1934.

PLAN OF THE STUDY

The Los Baños Cantonese chickens used in this study were reared under normal conditions until they attained the age of eight months. Body measurements were taken at five different stages: namely, at hatch, usually an hour or two after the chicks were taken off the incubator, at two months, at four months, at six months, and at eight months of age. In each set of observations, 20 birds were

[1] The figures reported in this paper are a part of those contained in the thesis presented by the junior author for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, University of the Philippines; Experiment Station contribution No. 1198.

used, 10 males and 10 females. The average weights of the birds measured were as follows:

AGE	MALES	FEMALES
	gms.	*gms.*
At hatch	29.1	30.9
2 months	331.3	340.8
4 months	768.9	797.9
6 months	1064.0	1096.5
8 months	1148.5	1339.0

Measurements taken. To obtain the width of the back, the distance between the bases of the wings of the birds was measured. The distance between the point of the hip and the point of the keel bone was taken as the depth of the body. The length of the body is

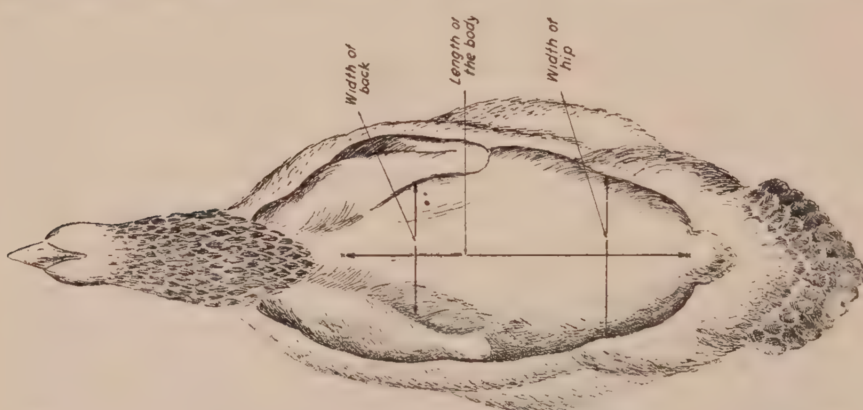

Fig. 1.—A diagrammatic drawing looking from the back of a Los Baños Cantonese pullet, with the feathers on the back removed, showing where the width of the back, width of the body, and the length of the body were measured

the distance between the base of the neck and the tail (from the head of the coracoid to the clavicum). The distance between the base of the neck and the ventral surface of the anterior end of the keel bone was considered depth of chest. The distance between the points of the right and the left hip bones was considered the width between the hips, and the distance between the end of the keel bone and the end of the pubic bones was considered span. These characters are diagrammatically shown in figures 1 and 2. In all cases, three measurements were taken and their averages were considered as the measurement of the particular character measured.

RESULTS AND DISCUSSIONS

The means of the different measurements of the body taken at different ages of the chickens studied are given in table 1.

Width of back. It may be observed that at hatch, the width of the backs of male and female Los Baños Cantonese chicks are practically the same. At two months of age, however, the width of the backs of the males was observed to vary from 3.3 to 4.1 centimeters with a mean of 3.7 ± 0.054 centimeters; that of the females varied from 4.6 to 5.6 centimeters with a mean of 4.0 ± 0.066 centimeters. At four months of age this character varied from 6.4 to 7.4 centimeters with a mean of 6.9 ± 0.086 centimeters in the males; and from 6.3 to 7.9 centimeters with a mean of 7.3 ± 0.065 centimeters in the females. At six months of age the width of the backs of the males varied from 9.7 to 9.9 centimeters with a mean of 9.8 ± 0.025 centimeters; of the females, 9.3 to 10.7 centimeters with a mean of 10.1 ± 0.031 centimeters. At eight months of age the back of the males had a mean of 11.1 ± 0.102 centimeters and that of the females, 12.0 ± 0.106 centimeters.

It may be seen from the data presented that the back was consistently wider in the females than in the males. At hatch the difference was not significant, but in the succeeding periods the differences became not only greater numerically but also significant statistically.

Depth of body. At hatch, the mean depth of the body of the males was 2.2 ± 0.024 centimeters and the females, 2.2 ± 0.085 centimeters. At two months of age the depth of the body of the males was 5.9 ± 0.069 centimeters; that of the females, 5.9 ± 0.076 centimeters. At four months of age, the depth of the body of the males averaged 9.8 ± 0.068 centimeters and that of the females, 9.4 ± 0.159 centimeters. At six months, the body of the males was 10.3 ± 0.263 centimeters deep and that of the females, 10.6 ± 0.176 centimeters. At eight months of age, the males averaged 11.6 ± 0.244 centimeters and the females, 12.4 ± 0.203 centimeters.

No significant difference between the male and female in depth of body was found in any of the periods studied. At hatch, at two, and at four months of age the greater body depth of the male was not marked. It may be noted, however, that at the ages of six and eight months of age, the depth of the body was greater in the females than in the males, although these differences were not significant.

Length of body. The data in table 1 show that at hatch the average length of the body of the males was 3.0 ± 0.065 centimeters; of the females, 3.3 ± 0.083 centimeters. At two months of age, the average length of the body of the males was 6.6 ± 0.089 centimeters, of the females, 6.9 ± 0.052 centimeters. At four months of age, the average length of the body of the males was 10.9 ± 0.092 centimeters; of the females, 10.9 ± 0.120 centimeters. At six months of age the average length of the body of the males was 16.2 ± 0.011 centimeters; of the females, 15.7 ± 0.129 centimeters. The mean

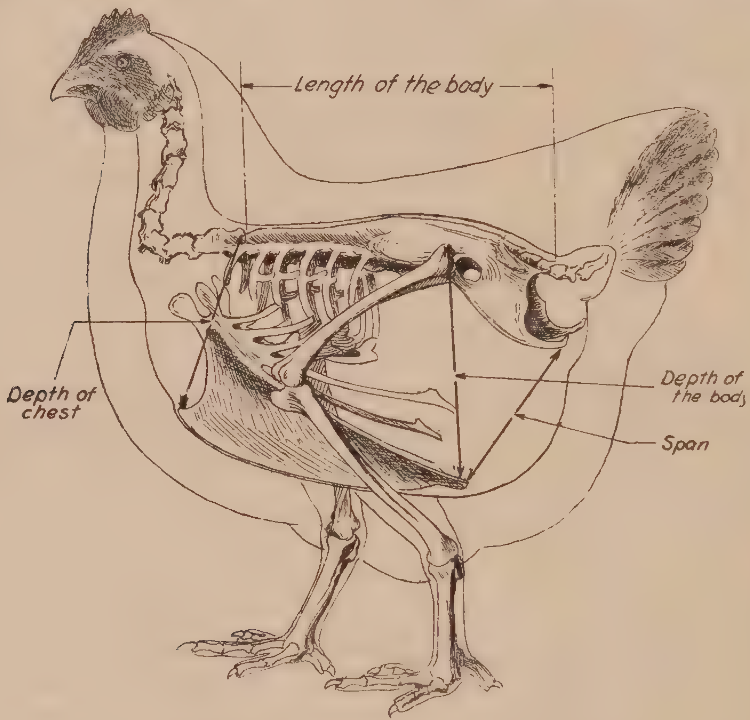

Fig. 2.—A diagrammatic "x-ray" drawing looking from the side of a Los Baños Cantonese pullet, showing where the depth of the body, length of the body, depth of the chest, and the span were measured

difference of 0.5 ± 0.129 centimeter at the age of six months was statistically significant. At eight months of age the average length of the body of the males was 18.6 ± 0.209 centimeters; of the females, 18.2 ± 0.172 centimeters. There was no significant difference found at this age. It may be seen, therefore, that the difference in the length of body in the male and in the female did not follow a regular trend.

Depth of chest. By further reference to table 1, it may be seen that the average depth of chest of the males at hatch was 2.1 ± 0.015 centimeters; of the females, 2.2 ± 0.034 centimeters. At two months of age, the average depth of the chest of the males was 5.5 ± 0.066 centimeters; of the females, 5.8 ± 0.052 centimeters. At the age of four months, the depth of the chest of the males had a mean of 9.2 ± 0.223 centimeters; that of the females, 10.0 ± 0.253; at six months, the depth of the chest of the males was 11.7 ± 0.016 centimeters, and the females, 12.3 ± 0.172 centimeters; and at eight months of age the chest of the males had a mean depth of 16.4 ± 0.174 centimeters, and the females, 16.2 ± 0.150 centimeters.

These figures show that in all ages studied the female Cantonese fowl consistently had a deeper chest than the males. The difference was not statistically significant at hatch and at the ages of two and four months. At the age of six months, the difference was 0.6 ± 0.175 centimeter, and at the age of eight months, 0.8 ± 0.229 centimeter. Both of these differences are statistically significant.

Width of hips. The width of the hips (table 1) at hatch was 2.1 ± 0.035 centimeters in the males, and 2.1 ± 0.047 centimeters in the females. At two months, the hips had a mean width of 4.1 ± 0.089 centimeters in the males, and 4.7 ± 0.024 centimeters in the females. At the age of four months, the width of the hips of the males had a mean of 6.3 ± 0.023 centimeters; of the females, 5.9 ± 0.116, or a difference of 0.4 ± 0.118 centimeter. At six months, the males had a mean width of hips of 7.6 ± 0.032 centimeters, and the females, 7.0 ± 0.116 centimeters, or a difference of 0.6 ± 0.120 centimeter. At eight months the distance between the hips of the males had a mean of 7.9 ± 0.120 centimeters; of the females, 8.2 ± 0.180 centimeters. These figures show that only at two and eight months of age were the female Los Baños Cantonese fowls significantly wider between the hips than the males.

Span. By further reference to table 1, it may be seen that at two months the mean span of the males was 2.0 ± 0.098 centimeters; of the females, only 1.8 ± 0.099 centimeters. At four months the average span of the males was 2.5 ± 0.108 centimeters; that of the females, 2.9 ± 0.108 centimeters. At six months of age, the males had a mean span of 3.1 ± 0.049 centimeters; the females, 3.4 ± 0.294 centimeters. At eight months the males had a mean span of 4.2 ± 0.156 centimeters, and the females, 5.1 ± 0.132 centimeters.

There was no consistent difference between the span of the male and the female Los Baños Cantonese fowls up to two months of age.

From four months, however, the females consistently had a wider span than the males, although it was only at the age of eight months that the difference became significant.

SUMMARY AND CONCLUSIONS

Various body measurements of male and female Los Baños Cantonese fowls taken at different ages are presented in this paper. The data obtained may be summarized as follows:

1. At six months of age, the mean width of the back of the male was observed to be 9.8 ± 0.025 centimeters; that of the female, 10.1 ± 0.031 centimeters. The female Los Baños Cantonese fowls were observed to have wider backs than the males.

2. No consistent differences were observed between the male and the female Los Baños Cantonese fowls in the depth and in the length of the body.

3. At six months of age, the body of the male Los Baños Cantonese fowl was observed to be 10.3 ± 0.263 centimeters deep and 16.2 ± 0.011 centimeters long; that of the female, 10.6 ± 0.176 centimeters deep and 15.7 ± 0.129 centimeters long.

4. The female Los Baños Cantonese fowl had a tendency to be deeper-chested than the male. At six months of age, the depth of the chest of the male was observed to be 11.7 ± 0.016 centimeters; that of the females, 12.3 ± 0.172 centimeters.

5. It was only at two and at eight months of age that the female Los Baños Cantonese fowls were significantly wider between the hips than the male. At six months, the male had a mean width of hips of 7.6 ± 0.032 centimeters, and the female, 7.0 ± 0.116 centimeters.

6. The female Los Baños Cantonese fowls, in general, had a tendency to have wider span than the male, particularly after the pullets had started to lay. At six months of age, the male had a mean span of 3.1 ± 0.049 centimeters; the female, 3.4 ± 0.294 centimeters.

LITERATURE CITED

RICE, J. E., G. O. HALL, AND D. R. MARBLE. 1930. Judging poultry for production. xii + 425 p. 205 fig. New York: John Wiley and Sons, Inc.

TABLE 1

Body measurements of male and female Los Baños Cantonese chickens at different ages

CHARACTERS	AT HATCH		TWO MONTHS		FOUR MONTHS
	Male	Female	Male	Female	Male
	cm.	*cm.*	*cm.*	*cm.*	*cm.*
Width of back	2.0 ± 0.029	2.1 ± 0.044	3.7 ± 0.054	4.0 ± 0.066	6.9 ± 0.086
Depth of body	2.2 ± 0.024	2.2 ± 0.085	5.9 ± 0.069	5.9 ± 0.076	9.8 ± 0.068
Length of body	3.0 ± 0.065	3.3 ± 0.083	6.6 ± 0.089	6.9 ± 0.052	10.9 ± 0.092
Depth of chest	2.1 ± 0.015	2.2 ± 0.034	5.5 ± 0.066	5.8 ± 0.052	9.2 ± 0.223
Width of hips	2.1 ± 0.035	2.1 ± 0.047	4.1 ± 0.089	4.7 ± 0.024	6.3 ± 0.023
Span	[a]	[a]	2.0 ± 0.098	1.8 ± 0.098	2.5 ± 0.108

CHARACTERS	FOUR MONTHS	SIX MONTHS		EIGHT MONTHS	
	Female	Male	Female	Male	Female
	cm.	*cm.*	*cm.*	*cm.*	*cm.*
Width of back	7.3 ± 0.065	9.8 ± 0.025	10.1 ± 0.031	11.1 ± 0.102	12.0 ± 0.106
Depth of body	9.4 ± 0.159	10.3 ± 0.2[illegible]3	10.6 ± 0.176	11.6 ± 0.214	12.4 ± 0.203
Length of body	10.9 ± 0.120	16.2 ± 0.011	15.7 ± 0.129	18.6 ± 0.209	18.2 ± 0.172
Depth of chest	10.0 ± 0.253	11.7 ± 0.016	12.3 ± 0.172	16.4 ± 0.174	16.2 ± 0.150
Width of hips	5.9 ± 0.116	7.6 ± 0.032	7.0 ± 0.116	7.9 ± 0.120	8.2 ± 0.180
Span	2.9 ± 0.108	3.1 ± 0.049	3.4 ± 0.294	4.2 ± 0.156	5.1 ± 0.132

[a] Not measured

A STUDY OF "SINGLE VALUE" SOIL PROPERTIES: MOISTURE RELATIONSHIPS, LOSS ON IGNITION, STICKY POINT, AND AMOUNT OF CLAY [1]

D. I. AQUINO AND THUAN KOMKRIS

Modern soil physicists have endeavored to evolve a test, the result of which may be expressed in terms of a single number, instead of a group of figures from the results of a detailed mechanical analysis. They have tried and succeeded in assessing the general character of the soil by the direct measurement of some physical property assumed to be possessed by the soil. Such, for instance, are the determinations of the moisture content or moisture relationships under defined experimental conditions, the colloidal properties, the hygroscopic coefficient, moisture equivalent, and wilting coefficient. All of these measurements have been referred to as "single value" determinations, and the properties studied have, for the sake of convenience, been spoken of as "single value" properties.

In the present study only a few of the principal "single value" properties were selected. They were those which can be measured by a simple apparatus, and which are known as a measure of some definite soil characteristic. The principal aim of the present investigation was to consider the usefulness of these "single value" soil properties as bases of specification, according to the suggestions made by several investigators along this line.

Review of literature

Davis and Adams (1927) pointed out that no single measurement serves to distinguish a soil, but that it is necessary to measure many properties to be able properly to compare or differentiate soils.

Robinson, McLane, and Williams (1929) stated that when it comes to characterizing the soil by laboratory examination, a knowledge of the amount of organic matter present in it is of great importance. According to them, in ordinary routine, organic matter is either not determined or is expressed as loss on ignition. The loss

[1] Part of the material in this paper was embodied in a thesis presented by the junior author for graduation in 1933 with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 860. Experiment Station contribution No. 1199. Received for publication September 10, 1937.

on ignition is known to be greater than the true organic matter content, but the general assumption is that the former is reasonably reliable as a basis for comparing the amounts of organic matter present in various soils.

Hardy (1923) took the soil "constant" determined by the onset of stickiness on moistening an air-dry soil to represent the point at which the free liquid films responsible for the internal tenacity of the structure are only just beginning to form. He assumed that it is only when the colloid material of the soil is fully saturated with water that external adhesion becomes manifest. Hence, the moisture content of a soil at the point of "stickiness", or at "sticky point", is taken as a measure of the total imbibition capacity of the colloid content.

West (1931) found that the "sticky point" is a convenient soil "constant" for use in correcting variations in soil texture in field studies of soil moisture, using the technique described by Keen and Coutts (1928). In measuring the value of "sticky point" determinations in field studies of soil moisture, West observed that there was a high degree of correlation between the moisture content and "sticky points" of soils in moisture equilibrium. He also pointed out the fact that if the moisture content of a soil was beyond the "sticky point", sampling was impracticable.

Keen and Raczkowski (1921), working on the relation between the clay content and certain properties of soil, reported that the apparent specific gravity and the true specific gravity of the soil varied inversely with the percentage of clay, while the moisture content and the volume expansion of the soil when saturated varied directly with the clay percentage.

Objects of the present work

The present investigation was undertaken to determine: (*a*) the moisture content of air-dry soil, as well as the moisture content in equilibrium with the atmosphere of 50 per cent relative humidity, (*b*) the loss on ignition of oven-dry soil, (*c*) the moisture content at "sticky point", (*d*) the percentage of clay fraction, and (*e*) the relative effects of organic and inorganic colloids on the "sticky point" and on loss on ignition.

Time and place of the present work

The investigation was conducted in the laboratory of the Department of Soils and in the biochemical laboratory of the Depart-

ment of Agricultural Chemistry, College of Agriculture, from May, 1932, to May, 1933.

MATERIALS AND METHODS

The soils used. In all, 70 soil samples were subjected to the complete set of determinations mentioned above. The samples selected are listed and tersely described in table 1. These soils showed a wide range of types and properties, varying from clay loam to fine sandy loam. A number of samples from depths below the surface soil were also included. Soils No. 1 to 50 were collected in India, in 1923. They were kept in cork-stoppered bottles, thus maintaining so far as possible their original state. Soils No. 51 to 60 were obtained from Baguio, Mountain province, in 1931, and soils No. 61 to 70 were obtained in 1932, from the Experiment Station of the College of Agriculture, Laguna, by a previous thesis student in the Department of Soils.

The soil samples used in this study were prepared in the following manner: A known weight of air-dry soil (from 100 to 500 grams) was pulverized with a wooden mallet, care being taken not to crush the gravel and other coarse materials. When pulverization appeared to be complete, the soil was passed through a sieve with round holes of 1 mm. diameter. The portion that did not pass through the sieve was put in a wide-mouthed bottle half filled with water. The soil was then shaken well and allowed to stand for a few hours. The contents of the bottle were then poured back into the sieve, and the water, together with the suspension of the fine material found in it, was allowed to drain off. The residual portion in the sieve was then thoroughly washed with water, air-dried, and weighed as the "coarse portion". The difference between the total weight of the sample taken and the weight of the coarse portion gave the weight of the "fine portion". The percentages of both the coarse and the fine portions were computed and presented in table 1. The principal aim in so preparing the samples was to have an accurate idea of the nature of the soils used in the study.

Determination of air-dry moisture content. In the determination of the air-dry moisture content, the analytical method of drying the sample in the electric oven was followed. Five grams of the prepared sample were placed in an aluminum can and subjected to a temperature of 105°C. for at least 24 hours. Constant weight was usually attained after that length of time. The difference between the weight of the air-dry soil and the weight of the oven-dry soil

gave the weight of moisture present in the sample in the air-dry state. The percentage of moisture was computed on the basis of the weight of the air-dry soil.

Determination of the moisture content at 50 per cent relative humidity. With this determination, the method proposed by Keen and Coutts (1928) was followed. About 10 grams of air-dry soil were placed in a porcelain crucible and exposed over dilute sulfuric acid (43.40 grams of concentrated sulfuric acid in 100 grams of solution at 25°C.) in an air-tight desiccator (10-inch diameter). The desiccator was then covered with a piece of black oil-cloth and kept in a closed locker at room temperature. The weight of the crucible with its contents was taken every two days, until it did not change by more than one milligram. It was then assumed that constant weight had been reached. The crucible was next transferred to another desiccator, which contained concentrated sulfuric acid, and was allowed to remain there as before until constant weight was reached. It was found that the whole process of exposing the sample over sulfuric acid up to the final weighing consumed a period of from 15 to 20 days. The difference between the weight of the sample kept over dilute acid and the weight of that same sample desiccated with concentrated acid was taken to represent the amount of moisture that was contained in the sample when in equilibrium with an atmosphere of 50 per cent relative humidity. Like the air-dry moisture content, the percentage was computed on the basis of air-dry soil. It was found by Keen and Coutts (1928) that, by this method of determination, "the final weighings of the soil after reaching equilibrium in the desiccator are probably accurate to within two or three milligrams, and the results are, therefore, reliable to about 0.02 per cent".

Determination of loss on ignition. The sample for the determination of loss on ignition was weighed in a porcelain crucible, and heated to dull redness in an electric muffle furnace until constant weight was obtained. After the first weighing for constant weight, enough saturated solution of ammonium carbonate was added to moisten the sample. The sample was then allowed to dry and again was ignited to dull redness. The purpose of adding the ammonium carbonate solution was to facilitate the elimination of all carbonates found in the sample. The loss in weight of the sample after ignition minus the weight of the moisture that was held in it in the air-dry state was taken to represent the weight of the volatile matter. The percentage of volatile matter, reported as "loss on ignition", was ex-

pressed on the basis of oven-dry soil. The loss on ignition, as has been found by several investigators, can not be accurately determined for there is bound to be some uncertainty in the end point, even after prolonged ignition at bright red heat.

Determination of "sticky point". Many terms have been suggested to mean "the moisture content at the point of maximum plasticity", as used by soil investigators in the West Indies. The accepted definition of plasticity is "the property of a substance which enables it to change its shape without rupture when subjected to pressure, the new shape being retained when the pressure is removed". Hence, the introduction of the terms "moisture content at the point of optimum workability", "at the point of development of exterior adhesion", and "at the point of stickiness". All of these terms are referred to as "sticky point", for the sake of brevity and convenience.

The "sticky point" is somewhat hard to determine at first, but after a little experience with the method has been gained by practice, it can easily be identified. In the determination, from 5 to 10 grams of soil were used. They were spread in a thin layer on a glass plate, and then moistened with enough distilled water to render the soil definitely wet and sticky. The mass was then scraped off from the glass plate with a stainless spatula, and kneaded with the fingers until the soil ceased to adhere to external objects. To confirm this stage of stickiness, the kneaded mass was cut through with the spatula. The "sticky point" was assumed to be reached when a smooth and clean cut could be made. The kneaded sample was then put in an aluminum can and weighed. It was dried in the electric oven at 105°C. until constant weight was reached. The difference in weight before and after drying the sample in the oven represented the moisture content at "sticky point". The percentage of moisture was computed on the basis of oven-dry soil.

Determination of percentage of clay. The International Method for the Mechanical Analysis of Soils, as adopted by the Agricultural Education Association of Great Britain, as described by Piper and Poole (1929), was used in the determination of the percentage of clay. Twenty-five grams of soil, previously treated with hydrogen peroxide to oxidize the organic matter, were placed in the Bouyouces stirrer, and distilled water was added to a depth of about two inches below the mouth of the container. After the addition of 10 ml. of 10 per cent solution of ammonium hydroxide, the soil suspension was stirred for from 9 to 15 minutes, depending upon the kind of soil used. The suspension was next transferred to a graduated cylinder,

and the volume made up to 1,250 ml. The contents of the cylinder were thoroughly shaken by repeated inversions of the cylinder for one minute, and then allowed to stand for about 18 to 19 hours, depending upon the temperature of the suspension. After that length of time, 20 ml. of the suspension were pipetted from a depth of 28 cm. below the surface into a tared porce ain evaporating dish. The time of pipetting was governed by the temperature of the suspension. It was found that if the suspension be allowed to settle at about 1 o'clock in the afternoon, at 8 o'clock the following morning (that is, after 19 hours), when the temperature of the suspension was exactly 27°C., the clay fraction could be pipetted. If the thermometer registered a higher temperature than 27°C., the time of pipetting was consequently earlier; and if the temperature was lower, the time was correspondingly prolonged, to comply with the standard time for sedimentation set up in the *International Method of Mechanical Analysis of Soils.*

The pipetted portion of the suspension was evaporated to dryness on an electric hot plate, and then transferred to the electric oven. The constant weight of the fraction was taken to be the weight of the clay fraction in the 20 ml. aliquot of the suspension. If this be X, the amount of clay in the 25 gram sample used can be found by the formula:

$$\text{Weight of clay in sample} = \frac{X \times 1250}{20} \text{ grams}$$

and the percentage of clay can then be expressed thus,

$$\text{Percentage of clay} = \frac{X \times 1250 \times 100}{20 \times 25}$$

Treatment with hydrogen peroxide. The action of hydrogen peroxide on a number of undecomposed plant materials was far from negligible, and it was still greater in the presence of soils (Richardson, 1931). The assumption is that the peroxide is without effect on the mineral portion of the soil, although this is not strictly true, because, as has been pointed out, "a small amount of mineral material is dissolved that comes principally from the clay fraction and consists of mixed sesquioxide and a small quantity of silica." Keen and Coutts (1928) stated that these materials when removed might

change the physical and physico-chemical properties of the mineral portion of the soil, but that the available evidence is rather against this claim.

About 50 grams of air-dry soil were treated with hydrogen peroxide. The sample was put in a tall 800-ml. beaker. One hundred and twenty ml. of the 6 per cent hydrogen peroxide (20 vol.) were added, and the suspension allowed to stand over-night to enable the peroxide to act slowly and completely on the organic content of the soil. The beaker was then placed on the electric hot plate. The contents were constantly stirred to prevent frothing over. After the reaction had subsided, a further addition of peroxide was made, and this process was repeated until no more frothing could be detected. The suspension was then allowed to cool. After cooling, 400 ml. of 0.2 N solution of hydrochloric acid were added. The contents were left over-night and then filtered through hard filter paper of 18 cm. diameter. The soil was washed three times with 100-ml. portions of distilled water. The washed soil was scraped off from the filter paper and allowed to dry on a large watch glass. After drying, it was pulverized, sieved, and kept in paper bags for further use.

OBSERVATIONS AND RESULTS

The description of the soil samples used in the present study and their corresponding separates of fine and coarse materials are presented in table 1.

The average figures obtained for different "single value" determinations are shown in table 2.

A correlation between various single values is shown in table 3, and the accuracy of "sticky point" determination is presented in table 4.

The moisture data, namely, those connected with the air-dry moisture determination, the moisture content in equilibrium with atmosphere of 50 per cent relative humidity, and the moisture content at "sticky point" of both the original samples and the samples treated with hydrogen peroxide, are strikingly interesting. In England, Keen and Coutts (1928), and Coutts (1929) found that the moisture content in equilibrium with atmosphere of 50 per cent relative humidity was almost equal to the air-dry moisture content. This might be explained by the fact that the average humidity in that country falls within the range of 50 per cent, so that the weight of any air-dry soil does not change much upon being exposed to the

atmosphere of 50 per cent relative humidity. In the Philippines, however, the annual mean humidity at sea level varies from 76.70 to 85.70 per cent. Naturally, the moisture content of any air-dry soil under local conditions should be expected to exceed that of the same sample when allowed to be in equilibrium with atmosphere of 50 per cent relative humidity. The results obtained in the present study clearly point out that tendency, as may be seen by comparing the values of A and R in table 2. As a "single value" constant, the quantity R is, of course, more dependable than A, since the former is obtained by bringing the soil to a definite relative humidity. The air-dry moisture content can not strictly be said to remain constant, as there are bound to be fluctuations in the humidity of the atmosphere at any time when the determination is made.

From a comparison of the values of A and R with those of C, So, and Io in table 2, it may be seen that as the values of A and R increase or decrease, there is a general tendency for the values of the three latter quantities to follow the same course. Likewise, the value of So varies directly with that of Io in all cases.

From this general and cursory examination of results, there seem to be indications that there exists a certain degree of correlation between the various "single values" obtained, and that these associations should receive a more detailed examination.

Accuracy of the method used in determining "sticky point." As has been stated, an accurate determination of the "sticky point" can be made after a little practice. Once experience of the method is gained, one can expect the results of one's task to be comparatively uniform.

It may be stated that there is not much difference between the duplicate determinations of the "sticky point" value. A better idea of the accuracy that was attained in determining the "sticky point" may be had by examining the frequency of the variations in the percentage between the 140 duplicate determinations made. This is shown in table 4. Out of the 140 determinations, 65 showed a difference between the duplicates of less than 0.5 per cent; 33, a difference of less than 1.0 per cent; and 33, a difference of less than 2.0 per cent. There are but nine determinations that show a difference of more than 2.0 per cent between the duplicates. From these figures, it may be safe to state that the "sticky point" determinations were fairly accurate.

Comparison of original soils and peroxide treated soils. In order to study the relative effects of organic and inorganic colloids on the

moisture content at "sticky point" and on the loss on ignition, the determinations of these two "single value" properties were repeated with all the soils after they had been treated with hydrogen peroxide. By comparing the figures in table 2, it may be seen that the values of the "sticky point" decreased with all the soils after the peroxide treatment. Likewise, the value of the loss on ignition was reduced as a result of the same treatment. The decrease in these two "single values" because of the effect of hydrogen peroxide gives a direct indication that the removal of organic matter from the soils materially affected their moisture content at "sticky point" and their loss on ignition. The question might arise as to why there was still some loss on ignition after the soil had been treated with hydrogen peroxide to remove the organic matter. Treatment with hydrogen peroxide does not necessarily imply a 100 per cent destruction of the organic matter. In fact, Keen and Coutts (1928) found that only about 75 per cent of the total organic matter present was removed by the treatment. Furthermore, as has been stated elsewhere in this paper, the loss on ignition cannot be taken to be identical with the total organic content. At best it can only give an approximate value of the organic matter present, and as it involves several other losses, the loss on ignition value does not exactly represent the actual organic matter content.

DISCUSSION OF RESULTS

Relationships between different quantities of "single value." In table 3, it may be seen that there is a decidedly marked correlation between every pair of "single values" considered, except between *Io*-*Ip* and *So*-*Sp* (0.1839 ± 0.0053), which show a relatively low association. The figures also reveal that there is almost a perfect correlation (0.9578 ± 0.0067) between *A* and *R*. A higher degree of correlation is recorded between *C* and *R* (0.8922 ± 0.0164) than between *C* and *A* (0.88[illegible] ± 0.0173). There is a marked correlation between *A* and *So* (0.8494 ± 0.0225) and *R* and *So* (0.8764 ± 0.0187), but the correlation between *R* and *So* is higher than the correlation between *A* and *So*. *Io* and *So* are also highly correlated, the coefficient of correlation being 0.8661 ± 0.0201. With the hydrogen-peroxide-treated soils, the value of the correlation between *Ip* and *Sp* (0.7843 ± 0.0310) decreased. Besides, being closely associated with *A* and *R*, *C* is also decidedly correlated with *Io* and *So*, though in a somewhat lower degree, the coefficient of correlation between *C* and *Io* being 0.6876 ± 0.0425 and that of *C* and *So*, 0.7496 ± 0.0353. The correlation between *Io* and *A* was high, 0.7432 ± 0.0361, and so was that between *Io* and *R*, 0.7731 ± 0.0324.

Rôle played by organic matter in "single value" determinations

As may be seen in table 3, the loss on ignition (*Io*) is closely associated with the "sticky point" (*So*), with the moisture content both in the air-dry state and in equilibrium with the atmosphere of 50 per cent relative humidity (*A* and *B*), and with the clay content (*C*). The association between *Io* and *So* is, however, the most marked, and suggests that the "sticky point" of any soil is largely controlled by the volatile material or the organic colloids present in it. The association between these two quantities can not be questioned, when a high degree of correlation is also recorded between them, even after the soils have been treated with hydrogen peroxide. These findings are similar to those of Keen and Coutts (1928) who found the coefficient of correlation between *Io* and *So* to be 0.8650 and that between *Ip* and *Sp*, 0.8790.

The conclusion arrived at by Bavier (1930) that the absorptive capacity of the soils for water was controlled to a large extent by the organic material present is verified by the results of the present study. The values of the coefficient of correlation between *Io* and *R*, 0.7731 $\pm$ 0.0324, and *Io* and *A*, 0.7432 $\pm$ 0.0361, as shown in table 3, suggest a decidedly marked association.

According to the value of the coefficient of correlation obtained for *Io* and *C*, there seems to be an indication that the clay content had something to do with the organic matter content of the soils under study. The suggestion which can possibly be offered is that the soils which contained the most clay had the tendency to retain more organic matter than those soils the clay content of which was less.

Physical significance of various "single values"

After a careful examination of the results obtained in the present study, it can not be denied that the determination of the various "single values" herein discussed is of special value to the study of soils, particularly to soil physics. The remarkably high degree of association between them serves to point out their significance in measuring soil properties, as suggested by Keen and Coutts (1928).

Opinions have also been expressed to the effect that "single value" determinations should be employed in connection with soil classification, and that they should also be applied to the physical and physico-chemical aspects of soil management.

SUMMARY AND CONCLUSIONS

A number of methods of "single" determinations have been discussed and have been followed in the present study. A detailed in-

vestigation has been made on 70 soils regarding their moisture relationships, loss on ignition, "sticky point", and clay content.

The results obtained may be summarized as follows:

1. All the "single values" which had been determined varied with the different soil types, depending principally on their clay content and loss on ignition.

2. The air-dry moisture content was found to be more than the moisture content at 50 per cent relative humidity. This was explained by the fact that under the local conditions at the time the relative humidity in the so-called air-dry state was higher than 50 per cent. The two quantities, however, were observed to vary in a parallel manner with the different soil samples.

3. Correlation coefficients obtained for the various pairs of "single values" showed that soils with greater percentages of clay fraction possessed higher ignition losses, moisture contents, and "sticky point" values.

4. The moisture contents of all the soils were apparently controlled by their clay contents.

5. The "sticky point" seemed to depend upon the organic and inorganic colloids (clay fraction) present, but a closer association was observed between it and the organic colloidal content.

6. The organic matter content was found to influence the water absorbing capacity to a large extent.

7. Removal of organic matter from the soils by treating them with hydrogen peroxide brought about a decrease in the "sticky point" value and in the loss on ignition.

8. The remarkably high degree of association between the various "single values" herein reported suggests the advantage of employing these measuring properties as bases for specification in the physical study of soils.

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TABLE 1

Original soil samples[a] used in the present study and their corresponding separates of fine and coarse materials

SAMPLE NO.	STOCK NO.	SOIL TYPE	DEPTH	TOTAL WEIGHT	WEIGHT OF FINE PORTION[b]	PERCENTAGE OF FINE PORTION	WT. OF COARSE PORTION[c]	PERCENTAGE OF COARSE PORTION
			cm.	*grams*	*grams*		*grams*	
1	30–C	Malwa clay loam	24–36	279.60	267.50	95.67	12.10	4.33
2	22–E	" " "	34–42	198.10	170.50	60.98	27.60	39.02
3	10–F	" " "	60–65	261.30	251.30	96.17	10.00	3.83
4	24–A	Sipra clay loam	0–12	215.60	198.40	92.02	17.20	7.98
5	27–A	" " "	0–12	164.00	151.60	92.44	12.40	7.56
6	19–A	" " "	0–12	184.40	164.60	89.26	19.80	10.74
7	21–A	" " "	0–12	115.00	111.90	97.30	3.10	2.70
8	24–B	" " "	12–24	144.80	138.80	95.86	6.00	4.14
9	19–B	" " "	12–32	275.30	142.70	66.28	72.60	33.72
10	21–B	" " "	12–24	117.00	114.70	98.03	2.30	1.97
11	27–B	" " "	12–24	212.20	194.90	91.85	17.30	8.15
12	19–C	" " "	36–48	267.20	185.40	69.39	82.60	30.61
13	27–C	" " "	24–36	212.40	192.40	90.58	20.00	9.42
14	24–C	" " "	24–36	145.40	138.80	95.46	6.60	4.54
15	21–C	" " "	24–36	248.50	241.60	97.22	6.90	2.78
16	27–D	" " "	36–48	296.40	272.90	92.07	23.50	7.93
17	13–D	" " "	36–48	216.00	209.70	97.08	6.30	2.92
18	21–D	" " "	36–45	248.00	234.40	94.52	13.60	5.48
19	7–D	" " "	36–48	261.80	231.00	88.23	30.80	11.77
20	51–D	" " "	36–48	311.40	301.70	96.89	9.70	3.11
21	7–E	" " "	48–50	258.70	327.40	91.27	31.30	8.73
22	31–E	" " "	48–60	277.80	263.30	94.78	14.50	5.22
23	21–E	" " "	43–60	244.00	199.90	81.93	44.10	18.07
24	27–E	" " "	48–60	299.20	272.40	91.04	26.80	8.96
25	13–B	Sipra-Ujjain	12–24	170.00	164.00	96.47	6.00	3.53
26	27–F	Sipra clay loam	60–72	360.50	327.30	90.79	33.20	9.21
27	21–F	" " "	60–72	254.90	218.90	85.88	36.00	14.12
28	36–G	" " "	72–78	237.50	228.90	96.29	8.80	3.71
29	21–G	" " "	72–84	230.80	217.40	94.19	13.40	5.81
30	21–H	" " "	84–96	286.00	241.50	84.44	44.50	15.56
31	29–A	Ujjain silt loam	0–6	249.20	236.20	94.78	13.00	5.22
32	28–A	" " "	3–9	240.00	225.00	93.75	15.00	6.25
33	13–E	Ujjain-Sipra	48–60	229.50	228.90	99.74	0.60	0.26
34	28–B	Ujjain silt loam	9–18	210.20	209.40	99.62	0.80	0.38
35	29–G	" " "	60–72	254.50	254.50	100.00	0.00	0.00

[a] As distinguished from samples treated with hydrogen peroxide
[b] Portion that passes through 1-mm. sieve
[c] Portion that does not pass through 1-mm. sieve

TABLE 1 (continued)

SAMPLE NO.	STOCK NO.	SOIL TYPE	DEPTH	TOTAL WEIGHT	WEIGHT OF FINE PORTION [b]	PERCENTAGE OF FINE PORTION	WT. OF COARSE PORTION [c]	PERCENTAGE OF COARSE PORTION
			cm.	*grams*	*grams*		*grams*	
36	55–A	Gwalior silt loam	0–8	185.90	185.90	100.00	0.00	0.00
37	15–B	" " "	12–21	230.50	230.50	100.00	0.00	0.00
38	35–C	" " "	27–48	220.00	219.80	99.91	0.20	0.09
39	15–C	" " "	21–36	234.40	234.40	100.00	0.00	0.00
40	15–E	" " "	48–64	268.20	268.20	100.00	0.00	0.00
41	16–G	" " "	76–82	261.40	205.10	78.46	56.30	21.54
42	32–C	Morar clay loam	18–30	234.60	234.30	95.61	10.30	4.39
43	32–F	" " "	42–54	280.20	261.40	93.29	18.80	6.71
44	32–F	" " "	54–66	268.10	249.60	93.10	18.50	6.90
45	36–A	Nurabad fine sandy loam	0–6	200.70	200.70	100.00	0.00	0.00
46	36–B	" " "	6–24	141.90	141.90	100.00	0.00	0.00
47	36–C	" " "	24–36	120.10	120.10	100.00	0.00	0.00
48	34–A	Susera silt loam	0–9	142 20	142.20	100.00	0.00	0.00
49	23–A	Shirpuri loam	0–8	237.70	224.20	94.32	13.50	5.68
50	37–A	Vindhyan fine sandy loam	0–2	282.40	212.40	75.21	70.00	24.79
51	6–A	Baguio	0–10	301.50	289.50	96.02	12.00	3.98
52	8–A	Baguio (dark phase)	0–20	378.80	233.70	48.81	245.10	51.19
53	11–A	" " "	0–12	404.50	206.50	51.05	198.00	48.95
54	12–A	" " "	0–5	282 20	233.30	82.67	48.90	17.33
55	13–A	Baguio	0–15	300.90	289.20	96.11	11.70	13.89
56	6–B	"	15–40	296 90	294.00	99.02	2.90	0.98
57	8–B	Baguio (dark phase)	25–45	302 20	279.30	92.42	22.90	7.58
58	11–B	" " "	15–30	306.90	254.60	82.96	52.30	17.04
59		" " "	10–20	476 90	293.20	61.48	183.70	38.52
60	13–B	Baguio	25–40	298.20	266.60	89.40	31.60	10.60
61	R1–7a	Calumpang clay loam	0–20	300.00	300.00	100.00	0.00	0.00
62	R1–8a	" " "	0–20	300.00	300.00	100.00	0.00	0.00
63	R2–6	" " "	0–20	300.00	300.00	100.00	0.00	0.00
64	R5–11	" " "	0–20	300.00	300.00	100.00	0.00	0.00
65	R6–10	" " "	0–20	300.00	300.00	100.00	0.00	0.00
66	R7–8	" " "	0–20	300.00	300.00	100.00	0.00	0.00
67	R7–4a	" " "	0–20	300.00	300.00	100.00	0.00	0.00
68	R7–7a	" " "	0–20	300.00	300.00	100.00	0.00	0.00
69	R8–7a	" " "	0–20	300.00	300.00	100.00	0.00	0.00
70	R8–9	" " "	0–20	300.00	300.00	100.00	0.00	0.00

TABLE 2

Summary of results [a]

SAMPLE NO	C	A	R	S_o	S_p	I_o	I_p	S_o-S_p	I_o-I_p
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	45.31	12.33	6.53	32.09	26.47	8.37	7.60	5.62	0.77
2	32.18	8.15	4.03	32.87	23.44	5.77	4.09	9.43	1.68
3	36.91	9.87	4.46	27.78	24.37	6.28	5.95	3.41	0.33
4	24.90	6.36	2.85	26.15	24.22	6.53	5.84	1.93	0.69
5	28.20	6.91	3.20	23.53	19.11	5.29	4.55	4.42	0.74
6	31.43	8.03	4.63	29.24	22.49	10.33	8.54	6.75	1.79
7	24.27	6.16	2.83	26.27	19.84	6.04	4.56	6.43	1.48
8	30.75	7.68	3.48	30.07	25.26	6.16	5.30	4.81	0.86
9	17.25	3.83	1.89	16.17	14.90	6.09	4.97	1.27	1.12
10	23.53	6.34	2.86	24.37	20.81	5.96	3.94	3.56	2.02
11	25.55	6.13	3.19	23.89	22.61	5.16	4.30	1.28	0.86
12	25.95	5.77	2.93	19.87	17.62	6.19	2.51	2.25	3.68
13	24.95	6.78	3.19	28.43	22.87	5.84	5.48	5.56	0.36
14	31.47	8.38	3.72	32.13	24.59	6.80	4.18	7.54	2.62
15	25.75	6.70	2.77	25.11	20.96	7.16	5.46	4.15	1.70
16	28.41	7.11	3.20	23.01	20.24	4.96	4.66	2.77	0.30
17	21.07	5.36	2.31	22.73	17.68	8.25	6.67	5.05	1.58
18	27.80	6.82	2.80	26.64	21.97	7.91	3.47	4.67	4.44
19	35.47	9.05	3.84	27.28	23.00	6.00	5.29	4.28	1.71
20	20.85	7.01	3.98	25.14	23.20	7.93	6.57	1.94	1.36
21	35.45	8.98	3.97	25.69	23.44	6.45	3.52	2.25	2.93
22	20.83	6.10	2.68	21.99	20.11	9.50	8.21	1.88	1.29
23	21.07	5.32	2.56	23.01	18.36	7.28	3.24	4.65	3.04
24	27.20	6.82	2.75	25.27	20.10	7.13	5.20	5.17	1.93
25	19.53	4.62	2.52	20.93	20.69	5.15	4.52	0.24	0.63
26	21.00	5.09	2.47	22.99	18.68	6.33	3.51	4.31	1.82
27	17.15	4.35	1.96	21.37	17.72	4.86	4.64	3.65	0.22
28	19.15	4.78	2.16	24.26	18.78	6.45	4.93	5.48	1.52
29	16.67	4.02	1.87	23.57	17.98	5.33	3.59	5.59	1.74
30	13.90	3.49	1.63	21.65	15.58	5.17	2.77	6.07	2.40
31	13.05	3.81	2.31	19.25	17.99	3.42	2.65	1.26	0.77
32	11.83	3.67	1.79	18.81	16.00	4.71	3.13	2.81	1.58
33	22.20	5.63	2.34	21.19	20.07	7.41	3.14	1.12	4.27
34	11.90	4.72	2.50	21.05	19.67	4.89	3.43	1.38	1.46
35	14.08	5.17	2.48	20.53	18.90	7.52	3.94	1.63	3.58
36	9.55	1.75	0.90	15.90	13.94	2.14	1.63	1.96	0.51
37	12.93	2.47	1.38	17.32	14.29	2.55	2.27	3.03	0.28

C = Percentage of clay in original samples
A = Moisture content of original air-dry samples
R = Moisture content of original air-dry samples at fifty per cent relative humidity
S_o = Moisture content of original samples at "sticky point"
S_p = Moisture content of peroxide-treated samples at "sticky point"
I_o = Loss on ignition of original samples
I_p = Loss on ignition of peroxide-treated samples
[a] Results given are averages of duplicate determinations.

TABLE 2 (continued)

SAMPLE NO.	C	A	R	S_o	S_p	I_o	I_p	S_o-S_p	I_o-I_p
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
38	18.67	4.07	2.11	18.81	18.38	3.95	3.85	0.43	0.10
39	22.18	4.35	2.17	18.45	18.03	3.85	3.56	0.42	0.29
40	20.68	4.55	1.89	19.40	18.67	3.91	3.09	0.73	0.82
41	10.07	2.46	0.96	17.70	16.93	4.94	3.88	0.77	1.06
42	20.83	6.26	2.85	20.42	19.49	6.22	4.87	0.93	1.35
43	22 87	6.36	2.81	22.63	19.41	5.73	4.81	3.22	0.92
44	20.37	6.25	2.83	22.41	19.78	6.14	5.80	2.63	0.34
45	7.75	1.26	0.71	10.77	10.51	1.67	0.93	0.26	0.74
46	15.09	3.42	1.84	15.57	14.56	2.52	1.53	1.01	0.99
47	14.55	2.71	0.94	16.13	14.65	2.64	1.99	1.48	0.65
48	14.05	3.28	1.63	16.72	16.42	2.91	2.45	0.30	0.46
49	19.75	3.32	1.14	14.68	14.17	5.69	4.81	0.51	0.88
50	9.40	1.48	0.47	11.30	10.69	2.41	1.69	0.61	0.72
51	58.13	10.30	5.50	42.63	37.32	16.45	12.87	5.31	3.58
52	22.55	11.15	4.97	41.83	37.24	14.18	11.36	4.59	2.82
53	36.08	11.53	5.87	46.01	39.82	19.35	15.26	6.19	4.09
54	35.18	12.17	5.41	50.17	48.54	24.82	24.41	1.63	0.41
55	38.15	9.83	4.70	37.37	15.39	12.27	12.27	0.20	3.12
56	39.50	12.97	5.70	44.03	43.87	12.78	10.28	0.16	2.50
57	20.65	12.29	5.51	41.23	38.86	11.27	9.87	2.37	1.40
58	38.30	13.14	6.09	42.97	41.74	11.37	10.48	1.23	0.89
59	42.65	12.02	5.81	42.71	36.51	13.09	10.43	6.20	2.66
60	39.90	13.19	5.45	44.83	43.59	11.54	9.16	1.24	2.38
61	57.80	12.79	6.11	34.03	31.27	8.66	7.86	2.76	0.80
62	62.25	15.47	6.75	40.05	34.19	10.01	8.70	5.86	1.31
63	53.70	12.00	6.00	34.05	32.79	11.87	9.17	1.26	2.70
64	56.45	12.61	5.65	34.18	32.34	10.72	9.35	1.84	1.37
65	58.07	12.42	5.90	35.50	33.01	11.29	8.05	2.49	3.24
66	59.22	11.93	6.05	35.24	31.65	11.75	9.60	3.59	2.15
67	53.00	13.71	5.82	38.07	32.77	10.02	9.44	5.30	0.58
68	56.43	15.24	6.50	46.75	34.27	10.52	8.84	12.48	1.68
69	53.71	13.19	5.80	34.22	31.35	10.71	9.99	2.87	0.72
70	56 98	11.80	5.77	34.41	32.53	12.15	9.93	1.88	2.22

TABLE 3

Correlation between various single values

SINGLE VALUES	COEFFICIENT OF CORRELATION	PROBABLE ERROR
A and R	0.9578	±0.0067
A and S_o	0.8494	±0.0225
R and S_o	0.8764	±0.0187
C and R	0.8922	±0.0164
C and A	0.8866	±0.0173
C and S_o	0.7496	±0.0353
C and I_o	0.6876	±0.0425
I_o and S_o	0.8661	±0.0201
I_o and R	0.7731	±0.0324
I_o and A	0.7432	±0.0361
I_p and S_p	0.7843	±0.0310
I_o-I_p and S_o-S_p	0.1839	±0.0053

C = Percentage of clay in original samples
A = Moisture content of original air-dry samples
R = Moisture content of original air-dry samples at fifty per cent relative humidity
S_o = Moisture content of original samples at "sticky point"
S_p = Moisture content of peroxide-treated samples at "sticky point"
I_o = Loss on ignition of original samples
I_p = Loss on ignition of peroxide-treated samples

TABLE 4

Accuracy of "sticky point" determination

DIFFERENCE BETWEEN DUPLICATE DETERMINATIONS	FREQUENCY
per cent	
0 - 0.5	65
0.5 - 1.0	33
1.0 - 1.5	17
1.5 - 2.0	16
2.0 - 2.5	2
2.5 - 3.0	3
3.0 - 3.5	0
3.5 - 4.0	2
4.0 - 4.5	1
4.5 - 5.0	1

CALLUS AND ROOT FORMATIONS IN STEM CUTTINGS OF KAPOK, ACHUETE, AND SANTOL [1]

PACIFICO G. JIMENEZ

WITH THIRTEEN PLATES

Horticulturists always observe the formation of callus in stem cuttings, and while development of callus tissue is invariably connected with rooting of stem cuttings under laboratory and field conditions, its formation and development have not been followed very closely in any of our common woody plants. It is a common experience that many flowering plants can be propagated easily by marcottage but not by stem cuttage. Previous investigations (Miraflores, 1915; Arana, 1934 [2]) have shown that some plants like santol [*Sandoricum koetjape* (Burm. f.) Merr.] and avocado (*Persea americana* Mill.) do not produce adventitious roots by stem cuttage, while they do by marcottage (San Pedro, 1935). The cause for the failure of stem cuttings to root has not been determined. This paper presents some results on the formation and development of callus in stem cuttings of kapok [*Ceiba pentandra* (Linn.) Gaertn.[3]], achuete (*Bixa orellana* Linn.), and santol [*Sandoricum koetjape* (Burm. f.) Merr.]. This also includes an account of the development of adventitious roots on those stem cuttings with and without additional treatments described in this paper.

MATERIAL AND METHODS

Numerous stem cuttings of santol, achuete, and kapok were collected from time to time from mature plants growing in the vicinity of the College of Agriculture, Agricultural College, Laguna, and in Baras, Rizal, from April, 1935, to January, 1937. They were cut smoothly to about thirty centimeters with their distal ends horizontal and their basal ends slanting, except those of kapok planted in

[1] Thesis presented for graduation, 1937, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 1084; Experiment Station contribution No. 1200. Prepared in the Department of Agricultural Botany under the direction of Dr. José B. Juliano.

[2] ARANA, R. R. DE. Some asexual methods of propagation of the santol. (Thesis presented for graduation for the degree of Bachelor of Science in Agriculture. 1934. Unpublished.)

[3] According to Willis (1919), this species is *Eriodendron anfractuosum* DC.

May and September, 1935, both basal ends of which were horizontal and wedge-shaped, respectively. After the cuttings were trimmed to the desired length, their distal ends were painted at once with dehydrated coal tar. The cuttings were then laid down one over the other in a pile and covered with a moist cloth, except for the painted ends, which were left exposed for the coal tar to dry. At this time, all, except those to which additional chemical treatment was given, were ready for planting. Usually twenty-eight hours were necessary to dry the coal tar.

In some sets, the cuttings were planted in sterilized sand in halved petroleum cans which in turn were placed in a large wooden box provided with electrically controlled bottom heat. The lots so treated were kept indoors. The others were planted in a mixture of equal proportions of sand and garden soil in halved petroleum boxes placed under the ornamental plants behind the laboratories of the Department of Agricultural Botany. About two centimeters of the basal ends of the cuttings were immersed for an hour in a one per cent potassium permanganate solution to disinfect them, but this proved detrimental (Pl. 12, fig. 52) after some time; so the practice was discontinued.

Daily collections of the planted cuttings were made. Pieces of the bark and portions of the wood from the basal ends were fixed and killed in formalin-acetic-alcohol (70 per cent) prepared according to the formula given by Chamberlain (1932). The material proved to be too hard for paraffin embedding even when softened first in 50 per cent hydrofluoric acid in 95 per cent ethyl alcohol for about eight days, so that most of the sections examined were cut with the aid of Spencer sliding microtome. The sections were stained in safranin-light green, triple stain, safranin-Delafield's haematoxylin, or Heidenhain's iron-alum haematoxylin with orange gold dissolved in clove oil as a counterstain.

Microchemical tests for starch in plantings were made daily or at intervals of from two to three days. In santol and achuete cuttings, less extensive tests of shorter duration were made because these usually became dry earlier than the kapok cuttings. For suberization, tests were made immediately after the cuttings had been made and every three hours thereafter. The cuttings tested were not planted but were kept in a moist bell jar. The methods employed in the qualitative microchemical tests were those adopted by Ecker-

son [4], Chamberlain (1932), and Molisch (1923). The following tests were used regularly: for starch, iodine with potassium iodide; for suberin, Sudan III. The ammoniacal gentian violet of Artschwager and Starret (1931) did not prove satisfactory for suberin test with the cuttings used in this study.

Because of the difficulty experienced in rooting stem cuttings of achuete and santol, especially those of the latter, from May to July, 1936, the writer tried to ring off a portion of the bark of stems of these two species growing in Baras, Rizal, and in Los Baños, Laguna, following the procedure given by Rolfs (1915) for mangoes. Cuttings from the ringed branches were made as prescribed above and planted in plots prepared for the purpose under a santol tree growing on the bank of a river in Baras, Rizal, and in halved petroleum boxes containing mixtures of equal amounts of sand and garden soil in the College of Agriculture, Laguna. Cuttings as controls were also made from unringed branches and treated as usual.

EXPERIMENTS AND RESULTS

Description of the cuttings

Macroscopical. Ceiba pentandra (Linn.) Gaertn. For convenience, kapok cuttings were classified into three groups: namely, (*a*) season's growth—branches (flushes) with full foliage, active buds, but no flowers up to that time (Pl. 1, fig. 2; Pl. 2, fig. 6-7); (*b*) year's growth—green branches which may or may not have yet fruited, dormant buds and leaves borne relatively on short lengths from their apices (Pl. 2, fig. 8–9) in contradistinction to those of (*a*); and (*c*) more than a year's growth—grayish branches with well-developed or extremely dormant buds (Pl. 1, fig. 1; Pl. 3, fig. 10–11). In all sets of plantings, the cuttings belonging to groups (*a*) and (*b*) were utilized except in May and September, 1935, when group (*c*) was used instead of (*b*).

All of the cuttings measured 30.5 centimeters long, except those in September, 1935, which measured 22.5 centimeters. The diameters at their basal ends were from 1.2 to 2.2 centimeters. Just after the cuttings were made, mucilage was observed on the pith at both ends. This was especially true of young cuttings (*a* and *b*). The lysigenous mucilage cavities in the pith secreted the mucilaginous exudate when the cuttings were made.

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[4] ECKERSON, S. H. Microchemistry. Mimeographed laboratory directions. 30 p. University of Chicago.

Bixa orellana Linn. Achuete cuttings were grouped into two kinds: namely, young, or softwood, and old, or hardwood. The young, or softwood, cutting was generally Saccardo's [5] umber having leaves and active buds. The old, or hardwood, cutting was leafless, mars brown to mummy brown, and had buds dead or dormant.

The cuttings were also 30.5 centimeters long, with diameters at their basal ends of from 1.1 to 1.8 centimeters for the softwood cuttings and from 1.2 to 2.2 centimeters for the hardwood cuttings.

Sandoricum koetjape (Burm. f.) Merr. Santol cuttings were also of two kinds. The young or softwood cuttings bore leaves, while the hardwood ones were leafless. The softwood cuttings were either tawny olive, vetiver green, or tea green, while the hardwood were mummy brown.

The cuttings measured 30.5 centimeters long. The younger ones had a diameter ranging from 1 to 2 centimeters, while the older ranged from 1 to 2.2 centimeters.

Microscopical. Ceiba pentandra (Linn.) Gaertn. In transverse section, group (*a*) cutting of kapok is nearly rounded. On the outside is a distinct layer of colorless epidermal cells (Pl. 9, fig. 39) which are rectangular and thin-walled with their outer tangential walls thick and distinctly concave. The cortex is comparatively narrow; on its outer portion is a single layer of colorless parenchyma possessing calcium oxalate crystals. Below this are seven to eight layers of parenchymatous cells in which chlorophyll is relatively abundant. Below this narrow region of chlorophyllous parenchyma are several large lysigenous mucilage canals. Two to three rows of nearly rounded and tangentially oblong parenchymatous cells also possessing scanty chloroplasts are found beneath these canals, limited inside by the pericyclic fibers.

The phloem portions have a nearly wedge-shaped contour and narrow outwards, while the phloem rays lying between them broaden outwards. The phloem fibers are more or less stratified. The phloem parenchyma as well as the phloem rays possess chloroplasts which are comparatively sparse. Few cells of these phloem rays possess calcium oxalate crystals. The cambium lying beneath the phloem portion is composed of a few layers of rectangular, thin-walled, and radially flattened cells.

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[5] In the determination of the color of the cuttings, Ridgway's (1912) *Color Standards and Color Nomenclature* was utilized to advantage.

The xylem portion is relatively a little less than half the size of the pith. Wood parenchyma is found abundantly throughout this region. Scattered among these parenchymatous cells are prosenchymatous cells which have thick walls and narrow or broad lumina. These parenchymatous and prosenchymatous cells possess no chlorophyll at all. Wood fiber cells are absent. The wood rays vary in breadth from one to four rows of cells.

The pith is homogeneous and consists of thin-walled, rounded to polygonal cells, wherein are located the mucilage canals containing colorless exudate. The smaller peripheral pith cells contain very little or no chloroplasts at all.

The transverse section of group (*b*) cutting is similar to group (*a*) in shape. Unlike that of group (*a*), the epidermal cells have their outer tangential walls rather indistinctly concave. The cortex below the epidermis consists of from six to seven layers of tangentially oblong parenchymatous cells, possessing dense chlorophyll and fairly abundant calcium oxalate crystals. Very often two to three layers of colorless collenchyma are found directly under those parenchyma. Beneath this narrow band of collenchyma are the mucilage canals somewhat similar in shape and number to those found in group (*a*). Beneath the mucilage canals are found three to four layers of thin-walled cortical cells; those found in the phloem rays are rectangular with their longer axes tangent to the stem. The pericyclic fibers are much more developed here.

The phloem portions are almost similar in every respect with those found in group (*a*) cutting except that the chlorophyll is more abundant in (*b*). Calcium oxalate crystals are also present in some of the cells of the phloem region. The phloem fibers are distinctly stratified, and between them are found the phloem parenchyma, sieve tubes, and companion cells. The phloem rays may vary from one to four cells in width and become broader centrifugally.

The woody portion occupies approximately more than half of the entire section. Wood perenchyma as well as prosenchyma are fairly abundant. Several concentric bands (Pl. 9, fig. 40) of thick-walled cells are present, indicating "seasonal growths." Wood fiber cells occur singly or in small groups. Calcium oxalate crystals are distributed here and there all over the wood section. The wood rays, like those of group (*b*) cuttings, vary in width from one to four rows of cells, which also contain calcium oxalate crystals. Chlorophyll is absent in the wood.

The pith is composed of thin-walled, rounded to polygonal cells and is rather narrow. The mucilage canals are also present. A few pith cells also contain calcium oxalate crystals.

The transverse section of group (*c*) cutting is similar to that of groups (*a*) and (*b*) in shape. Phellogen is present, and phellem serving as a protective covering is thus formed. Beneath this phellem are one to two rows of rectangular and tangentially flattened meristematic cells, the phellogen. Immediately below the phellogen cells are several layers of oblong to rounded or flattened phelloderm cells. Chlorophyll in the phelloderm is comparatively less now. The mucilage canals are still present, but they are rather shriveled or distorted, showing degeneration. The collenchyma is no longer present. Between these mucilage canals and the pericylic fibers are two to three layers of parenchyma which may contain comparatively less chlorophyll than those found in the same tissue in either (*a*) or (*b*) types of cutting.

The phloem portions have nearly wedge-shaped, stratified contours between which are the phloem rays possessing small amounts of chlorophyll. Calcium oxalate crystals are present in some of the cells and are a little more abundant in the cortical region. Chlorophyll is also present in the phloem parenchyma and phloem rays.

The wood portion in (*c*) cutting is broader than that of either the (*a*) or (*b*) cuttings. Wood fibers are relatively more here, and lignification of the cell elements is noticeable. The pith is homogenous, consisting of parenchymatous cells wherein are the mucilage canals.

Bixa orellana Linn. The transverse section (Pl. 11, fig. 47) of the softwood cutting of achuete is nearly rounded. The outermost covering consists of layers of phellem cells below which are a few layers of extremely flattened rectangular phellogen cells. Beneath the phellogen is the secondary cortex, or phelloderm, which is rather narrow, and consists of about eleven to twelve layers of small parenchymatous cells, which are green and oblong to rectangular. Oblong to rounded secretory cells are present in the cortex. The mucilage-secreting cells are within the first to the third layer of cortical cells adjacent to the phellogen. Calcium oxalate crystals may be found in some of the cells of the cortex.

The phloem portions lie beneath the secondary cortex. The phloem strands, which are long and slender, have a nearly wedge-shaped contour, and these narrow outwards while the primary phloem rays lying between them broaden in the same direction. The

phloem rays contain chloroplasts scattered uniformly throughout, but much less than those found in the cortical parenchyma. The phloem fibers are stratified. The cambium is rather thick and consists of as many as twelve layers of rectangular meristematic cells. The phloem rays may range from one to three layers of cells near the cambium. This number increases towards the cortex.

The wood occupies more than half of the entire portion of the section. Wood prosenchyma is fairly developed and contains no chloroplasts. The wood rays vary in width from one to two rows of cells.

The pith is relatively narrow and consists of homogeneous parenchymatous cells which vary in shape from nearly rounded to polygonal, and tend to enlarge towards the center. These pith cells possess practically no chloroplasts. Mucilage canals are present in the pith; one is in the center and the rest are around the periphery. Calcium oxalate crystals are also found in some of the cells of the pith.

The hardwood cuttings present nearly identical anatomical features found in the softwood cuttings. The phellem is more developed, while lignification in the wood is quite advanced. Formation of distinct wood fibers is discernible. The pith is very much smaller and exhibits similar arrangement of mucilage canals.

Sandoricum koetjape (Burm. f.) Merr. The softwood cutting of santol is nearly rounded in transverse section (Pl. 13, fig. 58). It is covered with a few layers of phellem cells, the inner and outer tangential walls of which are thick, while the radial ones are rather thin. Very often unicellular trichomes are still present on the outer portion of the phellem cells. These trichomes are, however, dead and are developed not from the phellem cells but from the already degenerated epidermal cells. Lying beneath the phellem are the phellogen cells which may vary from three to five layers in thickness. Below the phellogen are twelve to fifteen layers of oblong to rounded cells of the secondary cortex in which may be found groups of well-developed stone cells. The cortical cells contain relatively much less chlorophyll.

Before reaching the pericycle, four to five layers of tangentially oblong to nearly rounded cells are present. The pericyclic fibers are found at the apices of two to three strands of phloem.

The phloem portions lie beneath the pericycle. The phloem rays are radially rectangular and consist of parenchymatous cells containing few chloroplasts. The phloem rays may be composed of one

layer of cells which are rather large and elongated radially. Deposits of calcium oxalate crystals in the rays are noticeable. The cambium, which is several layers of cells thick, is well developed.

The wood occupies more than half of the entire section. Wood parenchyma is the predominating tissue. The wood rays are rather narrow, and range from one to three cells in breadth. As these rays emerge from the wood towards the phloem, they tend to decrease in number of cell layers to one.

The pith is relatively large and is slightly less than one-third the diameter of the section. It consists of thin-walled parenchymatous cells which are nearly rounded, polygonal, or cylindrical. Groups of sclerenchymatous cells are found in the pith, and these occur in groups which form patterns (Pl. 13, fig. 59) similar to cobwebs. Whether this anatomical feature of the pith has any significance on the behavior of the stem cuttings during a sexual propagation, the writer could not determine.

In cross-section the hardwood cutting is also nearly rounded in shape. On the whole the anatomical features found in this cutting are nearly identical to those described above. Some minor differences, however, are apparent. For example, the phellogen has increased in thickness and the stone cells which nearly form a ring around the stem now, are discernible. The wood has increased in diameter, and lignification of the wood parenchyma has set in. The pith is much smaller here.

Suberin formation

Priestley and Swingle (1929) have shown that cut surfaces of parenchymatous tissue become covered immediately with fine sap and broken cell fragments which offer a very suitable medium for the growth of micro-organisms. Decay would follow rapidly if changes in the walls beneath the surface film would not develop a barrier to impede the progress of the pathogenes. In the cuttings examined by the writer a temporary yet seemingly effective blocking off of the exposed surfaces at their basal ends was secured by suberization of the peripheral parenchymatous cell layers.

In santol cuttings, suberization of the peripheral parenchymatous cells in the two types of cuttings used took place at practically the same time. In as short as sixteen hours after the fresh cuttings had been placed in a moist bell jar, suberin deposition on the walls of the cells was detected. Suberization of the walls was very evident in the parenchymatous cells, but was absent in the walls of the fiber

cells of the pericycle, phloem, and wood. The pith cells also exhibited this distinct suberin reaction with the reagent. In the wood, however, the wood ray cells reacted with the Sudan III, clearly indicating that suberization also took place on their walls but only to a very slight degree. The first set of tests was made on June 21, 1936, and the second on January 7, 1937. The results of these tests were identical.

In achuete, the rate of suberization on the walls of the exposed parenchymatous cells from both the softwood and hardwood cuttings was somewhat slow; the first sign of positive reaction with Sudan III was detected only after twenty-seven hours from the time the cuttings were made. Suberization, which was absent in the wood, was mostly confined to the parenchyma of the cortex, phloem, and pith. Duplicate series of tests were carried out, and their results were nearly identical.

Kapok cuttings from the three types used in this study exhibited clear suberin reaction with Sudan III twenty and a half hours after they had been made. Two series of tests, carried out on the three types of cuttings, showed identical results. Suberization took place on the peripheral parenchyma of the cortex, phloem, and cambium; in the pith cells a very slight suberin reaction was detected.

Priestley and Swingle (1929) explain the process of suberization as follows: When the cuttings are made, a temporary increase in the permeability in the still-living protoplasts is brought about. If the strains are too severe, death may result. The intercellular spaces in the neighborhood of the cut gradually fill in with liquid which is not pure water but water that contains solutes, including fatty substances apparently released from the protoplast. The fatty substances undoubtedly arise from the sap which injects the intercellular spaces and the cell walls in the region of the cut. The result is that these substances accumulate at the water-air surfaces along the region of the cut; then, provided there is sufficient access of air, they immediately begin to change in chemical nature and are deposited as suberin in the cell walls and on the surfaces bounding the intercellular spaces.

Callus formation

Eames and MacDaniels (1925) believe that callus may be formed by the division of parenchymatous cells in the phloem and cortex, but its most frequent source is the cambium. Simon (Priestley and Swingle, 1929) states that callus in *Populus* cuttings is developed

through the repeated divisions of the cells of all the living tissues at the exposed surface including the pith. The cells in the neighborhood of the vascular cambium, however, are the most active in the process. Sharples and Gunnery (1933) observe that in stripped barks and on exposed surfaces of the wood of *Hibiscus rosa-sinensis* and *Hevea brasiliensis* the ray cells are responsible for the formation of callus, and the cambium is only secondary in its development. It seems apparent that the cambium is not always the source of callus in wounds of stems.

Formation of callus at the basal ends of stem cuttings used in this experiment are herein described. While the amount of callus formed in these typs of cuttings is apparently the same, there is a great difference in the rate at which callus is formed; kapok is the fastest, followed by santol and then achuete.

Ceiba pentandra (Linn.) Gaertn. The process of callus formation in the three types of cuttings used in this study is quite identical with slight differences in time and rate. Group (*a*) is the first in rate of callus formation, and this is followed very closely by groups (*b*) and (*c*).

The development of callus in stem cuttings of kapok is practically the same in all the types of cuttings employed in this study. Microscopical examinations reveal that no structural change in the cells at the periphery of the cut nor in those layers below it take place a few hours after the cuttings have been made. A day after (Pl. 6, fig. 27) the parenchyma at the periphery of the cut apparently acquire thickenings on their outer tangential walls, and in a few cases even on all the walls owing to the deposition of suberin. In other words, suberization of the walls takes place during the first day. The thick coating of granular substance outside the cells consists, perhaps, of some dirt together with exudate from the mucilage canals. This suberization process may proceed inward, involving several layers of cells, or may be confined to the outermost layer of parenchyma. The next change is the enlargement of the peripheral or hypodermal parenchyma (Pl. 7, fig. 33–34; Pl. 8, fig. 38) followed by tangential-wall formation. Because of this enlargement of the peripheral parenchyma, some of the adjacent hypodermal parenchymatous cells may be destroyed or displaced and eventually degenerate, and their walls become compressed. Proliferations of these enlarging parenchyma (Pl. 7, fig. 33-34) proceed until a distinct callus pad is formed on the cut surface (Pl. 10, fig. 46). Later, at the age of six days, a distinct cambial tissue of several cells in thickness is de-

veloped below the callus pad and this forms the phellogen near the basal end (Pl. 6, fig. 25). These phellogen cells in turn develop by tangential divisions the strong heavy callus to the exposed basal end of the cutting. The phellogen of the bark also exhibit active periclinal wall formation at the time the callus is being formed (Pl. 9, fig. 42) and this is responsible for the distinct enlargement of the cuttings at their basal ends.

Those parenchymatous cells at the phloem region also enlarge and elongate outward with their apices becoming globular and by tangential walls form a strong proliferation on the outside. The development of distinct phellogen below the cut is complete after the sixth day from planting the cuttings. Neither the pericyclic nor the phloem fibers whenever present participate in the production of the callus tissue; instead, both become buried in the callus pad.

The development of callus in the pith is very similar to that described above. Here, the peripheral pith cells adjacent to the wood are the first to show enlargement and strong proliferation (Pl. 10, fig. 45), and this activity proceeds centripetally.

Of interest to note in kapok cuttings is the production of tyloses in the xylem vessels near the cut ends of the cuttings (Pl. 10, fig. 43). According to Eames and MacDaniels (1925), development of tyloses either normally or as a result of wounding is due to (*a*) a difference in pressure in the cells on either side of the pith membrane, (*b*) reduction of pressure, or (*c*) cessation of conduction in the vessels permitting the membrane to expand into the vessels. In kapok, production of tyloses is due primarily, perhaps, to the difference in pressure resulting from the cut necessary in preparing the cuttings. The development of tyloses is most marked four days after planting. The tyloses, however, become buried in the developing callus pad formed from the phellogen below the cut.

Callus formation is not confined to the basal ends of the cuttings. This may occur even at their distal ends. It is worth noting that callus formation is more rapid in cuttings placed in a moist bell jar than in those actually planted in either sand or in equal parts of sand and garden soil, owing perhaps to the difference in oxygen supply.

Examinations of the transverse sections of the stripped wood and bark from kapok stems showed very interesting results. The stems were first severed from the parent plant and taken to the laboratory. Two vertical parallel cuts, about one centimeter apart, were made in the bark penetrating the wood. A third incision joining the two vertical cuts at the upper end was made, and the edge of

the bark gently lifted from the wood and pulled downwards without detaching it from the stem. The rectangular area of the wood so exposed and the lifted bark portion were protected from desiccation by a bandage of waxed tape wound around the stem with an overlap above and below of about half a centimeter. For the behavior of the phloem-ray cells, sections of the stems three centimeters long were incised, as described above, but the panel of bark was merely reflexed and held away from contact with the wood by a suitable wedge, and then covered by waxed tape. The stem pieces were placed and kept in the moist atmosphere of a large bell jar. In fact, except for a slight modification, the procedure followed by the writer was that used by Sharples and Gunnery (1933).

Wood sections revealed that three days after the above treatment, the wood-ray cells were already exhibiting a marked degree of enlargement and periclinal wall formation (Pl. 5, fig. 19). These processes continued until a mass of proliferating cells were formed above the outer surface of the wood (Pl. 5, fig. 22). In some cases, even ordinary wood parenchyma was involved in the production of some of these proliferating cells (Pl. 5, fig. 21), although most of the activity was confined to the wood ray cells.

In the bark, a similar behavior was observed. The phloem-ray cells were the first to enlarge (Pl. 5, fig. 23), and this took place just a day after receiving the treatment given above. The bark, therefor, showed an earlier growth than the wood, where the first sign of enlargement of the wood-ray cells was found to take place three days after the treatment. In the wound, the ray cells were the initial source of callus, as was also found by Sharples and Gunnery (1933) in *Hibiscus* and *Hevea*. The cambium is not the initial source of the callus, as has been ordinarily claimed (Eames and MacDaniels, 1925), and its part in wound healing is only secondary. On the lateral sides of the wound, the cortical cells, as well as the phloem-ray cells, elongate tangentially and by radial division form distinct lateral proliferations (Pl. 6, fig. 24) preparatory to the healing of the wound.

Microchemical tests of starch in kapok cuttings from groups (*a*), (*b*), and (*c*) used in this experiment showed that its distribution was fairly uniform for all the types used. Most of the starch grains were present in the wood rays and pith, and a little in the phloem and cortical regions. Starch grains were also detected in abundance at the basal peripheral cells of the cuttings just prior to planting in the media. Daily tests for starch on the three types of

cuttings showed a trend of starch migration. Long before the development of distinct phellogen below the suberized layer was evident, starch was present in all the cells in this region, but as these hypodermal cells began to show signs of active divisions, starch grains correspondingly disappeared. The disappearance of the starch grains seems to indicate that starch was used up in the formation of more protoplast in the hypodermal cells prior to their active divisions, or perhaps translocated elsewhere, a phenomenon also observed by Priestley and Swingle (1929) in seakle root.

Bixa orellana Linn. The development of callus in this species is practically identical to that reported for kapok. A day after the cuttings had been prepared there was no apparent change in the phloem region (Pl. 7, fig. 30), but distinct suberization was marked in the cortical region (Pl. 7, fig. 32). Proliferations were marked in the phloem ray cells (Pl. 8, fig. 36–37; Pl. 12, fig. 51, 55) after the fifth day, while the cortical cells did not exhibit such character. Instead, a distinct formation of phellogen cells (Pl. 6, fig. 28; Pl. 8, fig. 36–37; Pl. 11, fig. 48) below the suberized layer, about two to five cells thick, took place in the cortex. On the other hand, the pith cells showed no activity other than the suberization of the peripheral layer of cells.

Stripped bark and wood of achuete exhibited similar behavior to those observed in kapok. The only marked differences were found in the wood, where distinct layers of cambial cells remained attached to the wood after the bark had been detached, and these cambial cells apparently never showed any sign of activity (Pl. 5, fig. 18). The cambium of achuete stem is rather thick, and on detaching the bark some of the cambial cells actually remained attached to the wood. Instead of the cambium, the wood-ray cells showed active enlargement and proliferation.

Sandoricum koetjape (Burm. f.) Merr. The development of the callus in this species is mostly confined to the cambial region (Pl. 6, fig. 26, 29; Pl. 7, fig. 31; Pl. 9, fig. 41; Pl. 11, fig. 49). This was brought about by the enlargement and periclinal-wall formation of the cambial cells (Pl. 6, fig. 29) which resulted in the development of the callus pad around the wood. The phellogen of the bark (Pl. 7, fig. 35) near the cut basal end became heavily invested with strong development of tanniferous tissue, while the hypodermal cells were nearly hyaline and inactive.

Stripped bark and wood showed the same development as those described above (Pl. 5, fig. 20).

Development of adventitious roots

Ceiba pentandra (Linn.) Gaertn. Root formation takes place on the wound callus formed at the basal ends of the kapok cuttings (Pl. 2, fig. 9). In the process of callus formation, the newly formed phellogen below the cut, besides giving rise to callus cells, also produces vascular tissues embedded in the callus as regular or irregular loops following more or less the contour of the callus pad. Root initials seem to originate from the meristematic mass of cells of the newly formed phellogen below the cut, and this meristematic tissue very often is continuous with that from the phellogen of the bark. The root initials, being formed and differentiated therein, emerge to the outside (Pl. 10, fig. 44).

Six sets of plantings were made at different times: April 15, May 22, September 5, October 28, 1935, April 23, and July 20, 1936. In a set, sixty cuttings of each type were planted, except on two occasions when only sixteen of group (*a*), fifty of group (*b*), and ninety-five of group (*c*) were planted on April 23, and forty of group (*a*), twenty-two of group (*b*), and thirty-seven of group (*c*) on July 20. The first five sets of plantings were made in sand contained in halved petroleum cans provided with electrically controlled bottom heat, the temperature of which varied 1°C. from the room temperature. The last or sixth set of cuttings was planted in an equal mixture of sand and garden soil in halved petroleum boxes placed under the shade of ornamental plants growing at the northeast side of the Agricultural Botany Building.

The group (*b*) cuttings planted on April 15, 1935, rooted on April 29, 1935, fourteen days after planting, while none from group (*a*) rooted at all. Not one of either (*a*) or (*c*) cuttings planted on May 22, 1935, rooted. This may be due to the fact that groups (*a*) and (*c*) cuttings were either very young or very old. At the time the cuttings were gathered, the tree was flushing, and starch was noted in both. The condition of the tree seemed to have no bearing on the production of adventitious roots in this species because group (*b*) cuttings could produce roots whenever they were planted by the writer. These two types of cuttings (*a* and *c*) planted on September 5, 1935, did not produce roots. Microchemical examinations of these showed that very little or no starch reserves were present in group (*a*) cuttings, but were fairly abundant in group (*c*) cuttings. In the last type of cuttings, rooting was relatively impossible as the

majority of the cuttings died with but little or no bud growth. Repeated plantings of those two types of cuttings made on April 23 and July 20, 1936, did not produce roots.

Group (*b*) cuttings planted on October 28, 1935, rooted on November 11, 1935, fifteen days after the date of planting, while group (*a*) did not root. Those planted on April 23, 1936, rooted on May 4, 1936, eleven days after planting. The last or sixth planting took place on July 20, 1936, and roots were formed in group (*b*) cuttings on August 27, 1936, or thirty-six days after the time of planting.

With proper selection of material for planting and proper environmental conditions of moisture and temperature, roots may be expected to form in kapok cuttings even as early as eleven days from the time of planting. From the results given above, group (*b*) cuttings showed the best rooting response, and these may be recommended for planting material, as they can be gathered and planted any time with fair success. This does not, however, mean that group (*b*) cuttings are the only ones capable of propagating this species, as large branches of this plant take root quite readily.

Bixa orellana Linn. Literature shows divergent statements regarding the place of origin of stem-borne roots. According to Priestley and Swingle (1929), they may be pericyclic in origin on young stems, but in older stems they may arise from the neighborhood of the cambium. In either case, the roots are generally and intimately associated with the rays, and their origin involves more than one layer of cells. Ordinarily, achuete cuttings used in this study were not responsive to root production. Unless special care in the selection of planting material or special treatment was given, vegetative propagation of the plant was rather difficult with the size of cuttings used in this study. The planting material should come either from older branches, or from branches a portion of the bark of which had been ringed for at least forty-two days.

The use of older branches for planting in this species is suggested, for preformed roots were observed to be present in this type of cutting of achuete. Swingle (1929) recognizes the fact that hardwood cuttings may or may not have preformed small roots similar to those in Springdale apple, where roots may be detected in the bark of 3-year-old or older branches, but are absent in the younger wood. Apparently a certain degree of maturity is necessary before those preformed roots begin to develop.

Achuete seems to be similar to Springdale apple in its ability to exhibit preformed roots. The writer observed preformed small roots on the older branches of several achuete plants, and it was with the use of these branches that the first success in vegetatively propagating this plant was achieved. The writer ringed off a portion of the bark of the stem of achuete, as has long been recommended in the asexual propagation of mango (Rolfs, 1915). When thus ringed, preformed roots above the girdled portion were induced to develop and emerge from the bark (Pl. 1, fig. 3–5) after forty-two days under favorable conditions of moisture and atmospheric humidity. The roots, which seemed to have been differentiated from the cambium, worked their way outside through the lenticels (Pl. 12, fig. 54; Pl. 13, fig. 56). which had loose cells. Very often these lenticels produced intumescences (Pl. 12, fig. 53) above the ring. On several occasions, the callus formed at the base of the branch above the girdle of a 39-day-old ringed branch produced roots (Pl. 4, fig. 13) while still attached to the mother plant. The whole branch above the girdle was found to accumulate relatively more abundant colored substances, as well as starch grains than similar portions from an unringed branch (Pl. 12, fig. 54; Pl. 13, fig. 56). Carlson (1929) and Kraybill (1933) have shown that more reserve substances are responsible for the development of adventitious roots in stem cuttings as well as for greater flower bud formation in plants.

Out of the twenty-nine cuttings secured from unringed branches of achuete planted in plots prepared for the purpose in Baras, Rizal, on June 6, 1936, and July 3, 1936, only four rooted. These control cuttings were poor in root production. The roots of two of the cuttings emerged through the lenticels, clearly indicating that those adventitious roots were developed from preformed roots (Pl. 4, fig. 14); the other cuttings had roots arising from the callus (Pl. 4, fig. 15).

Cuttings obtained from previously ringed branches when planted in plots showed very interesting results. The thirty-three cuttings used were planted on June 6 and July 5, 1936. The cuttings just above the girdle which possessed callus (Pl. 4, fig. 14) before planting apparently showed better response to rooting and shoot formation, giving 50 and 80 per cent, respectively, than the subsequent cuttings (Pl. 4, fig. 14) above 30 centimeters from the girdle which gave a rooting response of 21.73 per cent for all cuttings combined, as well as 82.59 per cent for shoot formation. These meager data seem to indicate that for purposes of propagation the first 30 centimeters above the girdle should be utilized for propagation where

accumulation of starch was most evident, as shown by microchemical tests. It is also worthy of note that results of planting thirty-three cuttings from branches previously ringed for thirteen and forty-two days, respectively, showed that those cuttings obtained from branches ringed for forty-two days gave better results. It is, therefore, suggested that perhaps much better planting material for asexual propagation of achuete by stem cuttings will be produced if the time from girdling to cutting of the branches will be extended.

In the course of ringing achuete stems, shoot formation (Pl. 13, fig. 57) in the wound callus below the girdle was observed by the writer on several occasions on stems ringed on May 21, 1936. Plett in 1921 (Priestley and Swingle, 1929) stated that in some internodal cuttings where no remnant of the original bud base and meristematic cushion is left, the new buds usually arise from the wound callus. In *Salvia sylvestris* and *Acanthus mollis* the buds were confined to the distal callus; in some species, including *Boltonia latisquama, Physostegia virginiana,* and *Nicotiana,* most buds were formed upon the basal callus.

The formation of shoots from the wound callus is, perhaps, related to the condition obtaining in the vicinity of the girdled branches. Those which formed callus shoots were so placed under the shady part of the plant that humidity of the air might have played an important rôle in the formation of buds in the callus of achuete. Plett in 1910 (Priestley and Swingle, 1929) believed that gravity and light seem to produce little effect upon the position and production of these buds, but moisture exerted a very marked influence. The place of origin of the bud formed was not fully determined by the writer. Priestley and Swingle (1929) reported, however, that buds frequently appear from the phellogen formed in the wound callus, and this layer (phellogen) is visible very early in the fleshy roots, as in seakle.

Sandoricum koetjape (Burm. f.) Merr. No success was obtained in rooting ordinary santol cuttings (Miraflores, 1915; Arana, 1934). Santol is ordinarily not easily responsive to root production with the use of stem cuttings. Ringing off a portion of the bark as described above was somewhat effective for santol. Planting material should come from a branch ringed for thirteen days or more.

Adventitious roots from cuttings of santol originate from the callus tissue similar to that described for kapok (Pl. 3, fig. 12; Pl. 11, fig. 49). Roots may also arise, however, from the callus at the vicinity of the cambial region of the stem (Pl. 11, fig. 50).

No roots were produced from 607 santol softwood and hardwood cuttings planted in sand provided with bottom heat and in equal mixture of sand and garden soil in halved petroleum boxes. Soil moisture content of the media as well as the relative humidity of the air apparently had a very marked effect on inducing severe attack by a fungus suspected to be *Rhizoctonia solani* Kuhn [6] (Pl. 4, fig. 15). The cuttings dried up early. In this particular case, fungicides were not used.

Determinations of the amount of moisture lost by kapok cuttings when placed on the tables in the Laboratory of the Department of Agricultural Botany and in an electric oven at a temperature of 100°C. were made. Results showed that the thirty-three cuttings lost 39 per cent of their weight under laboratory conditions, and 58 per cent in the electric oven. These losses in weight were based on their initial fresh weight. Of the achuete cuttings, thirty lost 40 per cent of their weight in the laboratory, and 55 per cent in the electric oven. On the other hand, thirty-one santol cuttings lost 45 per cent of their weight in the laboratory, and 49 per cent in the electric oven.

Records of the loss of weight of individual cuttings for the three species placed on laboratory tables showed very interesting results. Each of the kapok cuttings, for example, lost from 3.51 grams to 2.20 grams every two-day period for eighteen days; achuete cuttings, 4.76 to 1.14 grams for fourteen days; and santol cuttings, 3.88 to 1.08 grams for sixteen days. The tendency of all the cuttings weighed was to lose more moisture soon after the cuttings were made; this loss decreased with length of exposure. It is worthy of note that achuete cuttings showed the greatest loss of moisture during the early weighings; kapok, the least. It was also observed that the rate of loss of moisture in achuete and santol cuttings was rather marked, and perhaps this accounted for the early drying up of these cuttings under conditions obtaining in the laboratory. Even if kapok cuttings gave up much moisture, they did not show early drying, inasmuch as they actually contained much initial moisture, that is, 58 per cent of their original fresh weight.

Another point considered in connection with the early drying of the cuttings of santol and achuete under conditions obtaining in the laboratory was the depth of planting. The cuttings were planted

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[6] Identified by Mr. Emiliano F. Roldan, of the Department of Plant Pathology.

in the sand at a depth of about seven centimeters. Trial plantings of sixty achuete softwood and hardwood cuttings each, at depths of 10, 15, and 20 centimeters, were made in the laboratory. The individual cuttings were weighed before planting. Seven days later, the cuttings were reweighed. Softwood cuttings showed an average loss of 18.17 per cent when planted at a depth of 10 centimeters; 14.42 per cent, at 15 centimeters; and 3.01 per cent, at 20 centimeters. The hardwood cutting gave loss of 19.93 per cent, 19.16 per cent, and 1.10 per cent, respectively, at these three depths. As expected, deeper plantings prevented rapid loss of moisture under laboratory conditions. Whether deeper planting would actually induce better rooting response in these two types of cuttings, the writer was unable to determine.

Would painting the proximal end of the cuttings used in this experiment reduce the loss of moisture? Paint-treated hardwood and softwood cuttings of achuete were planted in sand to a depth of 15 centimeters in the laboratory. Similar untreated cuttings were planted as control. These cuttings were weighed individually before being planted in sand, and after five and seven days from the time of planting. Five days after planting, each treated softwood cutting lost on the average 4.22 per cent of its weight, while the control lost 4.74 per cent. Seven days after, each treated cutting lost 6.08 per cent more of its weight, while the control lost 3.45 per cent. On the other hand, the treated hardwood cutting lost 3.60 and 6.16 per cent of its weight after five and seven days, respectively; the control lost 4.22 per cent after five days, but no more after the seventh day. The very meager results shown above do not warrant the formulation of any definite conclusion, but they show indications that at least for the first days more moisture escaped from the untreated cuttings than from the treated ones.

To supplement data obtained from the laboratory, the writer planted santol cuttings in plots in Baras, Rizal, on June 6, July 5, and July 13, 1936. Observations of the planted material was made twenty-nine, fifty-six, and sixty-four days after planting. From the sixty-four cuttings used in the three sets of planting given above, surprising results were noted. Twenty-nine days after planting, two of them showed formation of roots; after fifty-six days, three more, and after sixty-four days, two more showed similar results. The others only formed callus or showed development of their lateral buds. Many did not show any sign of growth at all.

It seems, therefore, that rooting in the cuttings utilized in this experiment was earlier than that obtained by Miraflores (1915) and Arana (1934) on marcottage. These investigators were able to root marcotted branches 109 to 118 days, and 130 days, respectively, from the time of girdling.

Cuttings from ringed branches of this species were also planted on June 6, June 28, July 5, and July 13, 1936. The time from girdling to cutting of branches were 13, 39, 43, and 50 days, respectively. One hundred and thirteen cuttings in all were prepared. Some were planted in an equal mixture of sand and garden soil in halved petroleum boxes placed under the shade of ornamental plants near the Department of Agricultural Botany, while the rest were planted in plots in Baras, Rizal.

Results showed that cuttings obtained 30 centimeters above the girdle and which possessed callus before planting gave better response to rooting (65.50 per cent) and shoot formation (65.50 per cent) (Pl. 4, fig. 16) than similar cuttings taken 30 centimeters above the ring (Pl. 4, fig. 17). The response to rooting and shoot development of the succeeding cuttings of 30 centimeters each in length was 25.00 and 75.00 per cent for the second, 16.66 and 58.51 per cent for the third, 0.0 and 83.22 per cent for the fourth, 9.09 and 45.45 per cent for the fifth, and 0.0 and 16.66 per cent for the sixth, respectively. It is apparent that these latter cuttings, however, gave much less response to rooting and high shoot formation compared with those obtained 30 centimeters above the girdle (Pl. 4, fig. 17). Consequently, the first 30-centimeter portion of the girdled branch must be preferred for propagating santol.

SUMMARY AND CONCLUSIONS

Results of observations on the development and formation of callus and suberization of the cells at the basal ends of stem cuttings of kapok, achuete, and santol, and an account of the development of adventitious roots in these cuttings are given.

Suberization in stem cuttings of these three species, determined with the use of Sudan III, took place in the parenchymatous cells of the cortex, phloem, and pith, and this was evident 20.5 hours, 27 hours, and 16 hours for the three species, respectively, after the cuttings were prepared and kept in moist bell jars.

The rate of callus formation was dependent on the species: kapok showed the fastest, followed by santol and achuete, respectively. In the different groups of kapok cuttings, group (*a*) callused first,

followed very closely by groups (*b*) and (*c*). In santol cuttings the development of callus was mostly confined to the cambial region, whereas in achuete callus was observed to develop in the bark. In kapok, the bark as well as the pith formed callus.

In wound healing, the wood and phloem-ray cells were the initial source of callus. On the lateral sides of the wound, cortical as well as phloem ray cells elongated tangentially and by radial walls formed distinct lateral proliferations.

In kapok cuttings, root formation took place on the wound callus at the basal ends, and these roots seemed to originate from the newly formed phellogen below the suberized layer; this was also true with santol cuttings. Under ordinary conditions (outside, without bottom heat) roots were formed as early as eleven days from the time of planting kapok cuttings, and twenty-nine to sixty-four days for santol. In achuete, adventitious roots were formed either from the callus or from preformed roots which emerged through the lenticels. Sixty-eight days after achuete cuttings had been planted, the adventitious roots were observed to be well-developed.

Of the three types of kapok cuttings used in this study, group (*b*) cuttings proved to be the best for propagating this species by stem cuttage. Non-rooting of groups (*a*) and (*c*) cuttings might be ascribed to the fact that they were either too young or too old for planting purposes. For propagating achuete, hardwood cuttings proved to be good material.

Ringing off portions of the bark of stems before planting proved to be conducive to successful propagation of achuete and santol. For achuete, branches ringed for at least forty-two days gave the best result; cuttings prepared directly above the girdle should be used. Subsequent cuttings from the same girdled branch proved much less proficient in forming roots.

Development of adventitious shoots and adventitious roots from the callus formed at the girdle of ringed achuete branches was observed on several occasions.

Results obtained from cuttings of the three species studied which had been planted in sand provided with bottom heat and placed in the laboratory, did not show favorable rooting response under the conditions then existing. Planting the cuttings in plots provided with good shade proved to be more beneficial for the successful rooting of these cuttings, and is, therefore, recommended for further trials.

Results seem to indicate the possibility of propagating by stem cuttage the three species studied. This is especially true with santol which ordinarily takes 109 to 130 days (Miraflores, 1915; Arana, 1934) for marcotted stems to root, whereas under conditions existing in this experiment, stem cuttings produced roots as early as twenty-nine days after planting, although the percentage of success, 65.5 per cent, was much less.

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EXPLANATION OF PLATES

(All photographs were taken by the Photographic Division, College of Agriculture. The photomicrographs (fig. 18-38) were taken by Dr. José B. Juliano, while the others (fig. 39–59) were taken by the author.)

PLATE 1

Ceiba pentandra (Linn.) Gaertn. and Bixa orellana Linn.

FIG. 1. Photograph of hardwood cuttings, group (*c*), of kapok, showing callus formation without root development. Planted on May 22, 1935, and photographed September 16, 1935. × 1/5.

FIG. 2. Photograph of softwood cuttings, group (*a*), of kapok showing shoots and callus but without any roots formed. Planted on May 22, 1935 and photographed September 16, 1935. × 1/3.

FIG. 3. Photograph of a portion of a stem of achuete showing formation of adventitious roots on the first and second internode above the girdle or ring, while still on the mother plant (ringed on May 25, 1936, and photographed on July 6, 1936). Note marked formation of intumescences in the lenticels. × 3/4.

FIG. 4. Photograph of a portion of the same stem (fig. 15) showing adventitious roots at the fourth and fifth node above the girdle. × 3/4.

FIG. 5. Photograph of a portion of the same stem (fig. 15-16) showing adventitious roots formed at the sixth node above the girdle. × 3/4.

PLATE 2

Ceiba pentandra (Linn.) Gaertn.

FIG. 6. Photograph of stem cuttings, group (*a*), showing development of shoots. Planted on April 23, 1936, and photographed on May 20, 1936. × 1/6.

FIG. 7. Photograph of a few cuttings from fig. 18 showing callus formation. × 1/6.

FIG. 8. Photograph of older cuttings, group (*b*) exhibiting vigorous formation of shoots. Planted on April 23, 1936, and photographed on May 20, 1936. × 1/6.

FIG. 9. Photograph of a few cuttings from fig. 20 showing callus and root formation. Photographed on May 20, 1936. × 1/6.

PLATE 3

Ceiba pentandra (Linn.) Gaertn. and Sandoricum koetjape (Burm. f.) Merr.

FIG. 10. Photograph of hardwood cuttings, group (*c*), of kapok showing shoots. Planted on April 23, 1936, and photographed on May 20, 1936. × 1/6.

FIG. 11. Photograph of a few cuttings from fig. 22, showing shoots and callus formation. × 1/6.

FIG. 12. Photograph of 58-day old santol cuttings showing roots and callus ringed for 49 days. Photograph on September 8, 1936. × 1/4.

PLATE 4

Bixa orellana Linn. and Sandoricum koetjape (Burm. f.) Merr.

FIG. 13. Photograph of an achuete branch (ringed for 39 days but not planted) showing development of roots at the callus above the girdle. Photographed on September 8, 1936. × 3/4.

FIG. 14. Photograph of an achuete cutting (to the left) ringed for 48 days and planted for 53 days, showing roots arising from the lenticels. The one to the right is the second piece from and above the girdle showing roots from the callus. All were photographed on September 8, 1936. × 3/4.

FIG. 15. Photograph of an achuete cutting (to the left), ringed for 13 days, showing callus and fungal attack. The one at the middle is the second piece from and above the girdle showing no callus formation; the one to the right is an unringed stem from older branch, 68 days from planting, showing development of roots. All photographed on September 8, 1936. × 3/4.

FIG. 16. Photograph of a santol cutting (ringed for 48 days and 53 days in the plats), showing development of roots at the callus above the ring. Photographed on August 28, 1936. × 3/4.

FIG. 17. Photograph of a santol cutting (second piece from and above the ring) from fig. 28 and 53 days from planting) showing development of roots at the callused portion. Photographed on August 28, 1936. × 3/4.

PLATE 5

Bixa orellana Linn., Sandoricum koetjape (Burm. f.) Merr., and Ceiba pentandra (Linn.) Gaertn.

FIG. 18. Transverse section of a stripped wood of achuete (1 day old) showing enlargement of the wood ray cells. × 95.

FIG. 19. Portion of a transverse section of a stripped wood of kapok (3 days old) showing enlargement and periclinal wall formation in a wood ray cell. × 237.

FIG. 20. Portion of a transverse section of a piece of stripped wood of santol stem (2 days old) showing enlargement of wood ray cells. × 95.

FIG. 21. Portion of a transverse section of a piece of stripped wood of kapok (4 days old) showing strong development of callus pad resulting from proliferations of wood ray and parenchymatous cells. × 95.

FIG. 22. Portion of a transverse section of a piece of stripped wood of kapok (8 days old) showing proliferations of wood ray cells. × 95.

FIG. 23. Portion of a transverse section of a piece of stripped bark of kapok (1 day old) showing enlargement of the phloem ray cells. × 95.

PLATE 6

Bixa orellana Linn., Sandoricum koetjape (Burm. f.) Merr., and Ceiba pentandra (Linn.) Gaertn.

FIG. 24. Portion of a transverse section of the bark of a stem of kapok (8 days old), at the edge of the wound showing elongation and proliferations of the phloem ray cells. × 95.

FIG. 25. Portion of a longitudinal section of the bark of kapok (6 days old) showing development of phellogen below the suberized layer. × 95.

FIG. 26. Portion of a longitudinal section of the bark of a santol hardwood cutting showing development of callus at the phloem and cambial region. × 85.

FIG. 27. Portion of a longitudinal section of a kapok stem (1 day old) showing suberization and thickening of outer tangential walls of the peripheral parenchyma. A mucilage canal is also shown. × 95.

FIG. 28. Portion of a longitudinal section of the bark of an achuete softwood cutting showing phellogen formation below the suberized layer. × 95.

FIG. 29. Portion of a longitudinal section of a santol hardwood cutting showing formation of proliferations of the cambial cells (4 days old). × 95.

PLATE 7

Bixa orellana Linn., Sandoricum koetjape (Burm. f.) Merr., and Ceiba pentandra (Linn.) Gaertn.

FIG. 30. Portion of a transverse section of an achuete cutting (1 day old) showing peripheral cells of the phloem region. × 95.

FIG. 31. Portion of a longitudinal section of a santol hardwood cutting (5 days old) showing development and proliferations of the cambial cells. × 85.

FIG. 32. Portion of a longitudinal section of an achuete softwood cutting (2 days old) showing distinct thickenings of the walls of the peripheral parenchyma and crushed walls at the cut end. × 95.

FIG. 33. Portion of a longitudinal section of a kapok cutting (4 days old), group (*b*), showing proliferations of the phloem ray and parenchymatous cells. Note the fiber cells. × 95.

FIG. 34. Portion of a longitudinal section of a kapok softwood cutting (3 days old), group (*a*), showing proliferations of the phloem ray cells. × 95.

FIG. 35. Portion of a longitudinal section of a santol hardwood cutting (1 day old) showing the phellogen from the bark. × 95.

PLATE 8

Bixa orellana Linn. and Ceiba pentandra (Linn.) Gaertn.

FIG. 36. Portion of a longitudinal section of an achuete hardwood cutting (7 days old) showing development of phellogen below the suberized layer in the cortex and proliferations of the phloem ray cells. × 95.

FIG. 37. Portion of a longitudinal section of an achuete softwood cutting (5 days old) showing phellogen below the suberized layer of the cortex and proliferations of the wood ray cells. × 95.

FIG. 38. Portion of a longitudinal section of a kapok cutting (3 days old), group (*b*), showing initial enlargement of the phloem parenchyma and phloem ray cells. × 95.

PLATE 9

Ceiba pentandra (Linn.) Gaertn. and Sandoricum koetjape (Burm. f.) Merr.

FIG. 39. Portion of a transverse section of a kapok stem, group (*a*), showing the bark and a part of its wood. × 48.

FIG. 40. Portion of a transverse section of the wood of a kapok stem, group (*b*), showing the "growth" ring. × 390.

FIG. 41. Portion of a longitudinal section of a santol cutting showing callus after being placed in a moist bell jar for 15 days. × 48.

FIG. 42. Portion of a longitudinal section of the bark of a kapok stem near the callus tissue showing activities of the phellogen. × 48.

PLATE 10

Ceiba pentandra (*Linn.*) *Gaertn.*

FIG. 43. Portion of a longitudinal section of the wood showing tyloses in the xylem vessel 14 days after being kept in a moist bell jar. × 48.

FIG. 44. Portion of a longitudinal section of the callus at the cortex showing root development. × 48.

FIG. 45. Portion of a longitudinal section of the callus derived from the pith cells from a cutting placed for 8 days in a moist jar. × 48.

FIG. 46. Showing callus formation at the bark near the cambial region from a cutting placed in a moist bell jar for 8 days. × 48.

PLATE 11

Bixa orellana Linn. and Sandoricum koetjape (*Burm. f.*) *Merr.*

FIG. 47. Portion of a transverse section of an achuete cutting showing the bark and portion of the wood. × 48.

FIG. 48. Portion of a longitudinal section of the bark from an achuete cutting showing callus (4 days after being kept in a moist bell jar). × 48.

FIG. 49. Portion of a longitudinal section of a santol cutting showing callus formation at the cambial region (15 days after being kept in a moist bell jar). × 48.

FIG. 50. Portion of a longitudinal section of a santol cutting showing root formation at the cambial callus tissue. Taken from 12 day-old ringed stem and 50 days after planting. × 18.

PLATE 12

Bixa orellana Linn.

FIG. 51. Portion of a longitudinal section showing callus, from an 8-day old cutting kept in a moist bell jar. × 48.

FIG. 52. Portion of a longitudinal section of the bark showing fiber cells sticking out of the callus tissue as an effect of the treatment with an aqueous one per cent solution of potassium permanganate. × 48.

FIG. 53. Longitudinal section of a lenticel showing intumescences. × 48.

FIG. 54. Portion of a longitudinal section of the bark of a ringed stem showing adventitious root emerging through it. × 18.

FIG. 55. Showing callus from a 7-day old cutting kept in a moist bell jar. × 42.

PLATE 13

Bixa orellana Linn. and Sandoricum koetjape (*Burm. f.*) *Merr.*

FIG. 56. Portion of a longitudinal section of an achuete ringed stem showing root embedded in its bark. × 18.

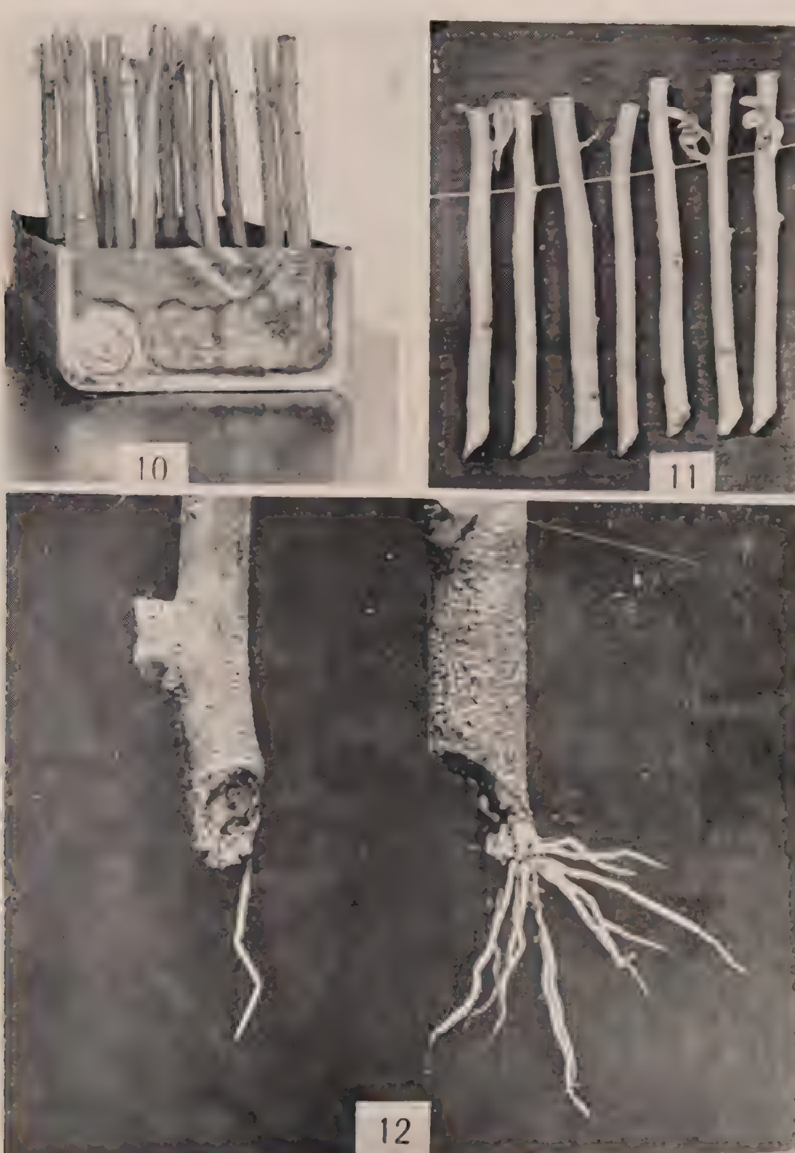
FIG. 57. Portion of a longitudinal section of an achuete ringed stem showing development of adventitious bud below the girdle while still attached to the mother plant. This was ringed on May 21, 1936, and examined on June 18, 1936. × 48.

FIG. 58. Portion of a transverse section of the stem of santol showing part of the wood and the pith. × 18.

FIG. 59. Portion of the same stem (fig. 58) showing the bark and part of the wood. × 18.

PLATE 1

PLATE 2



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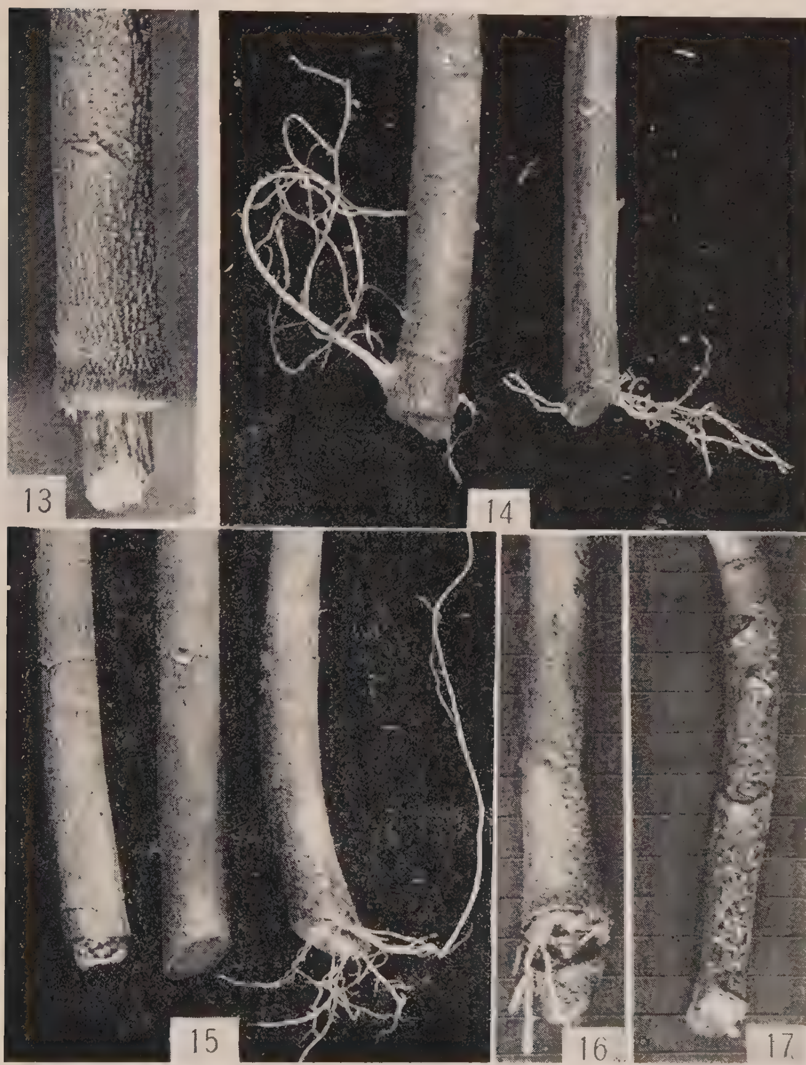

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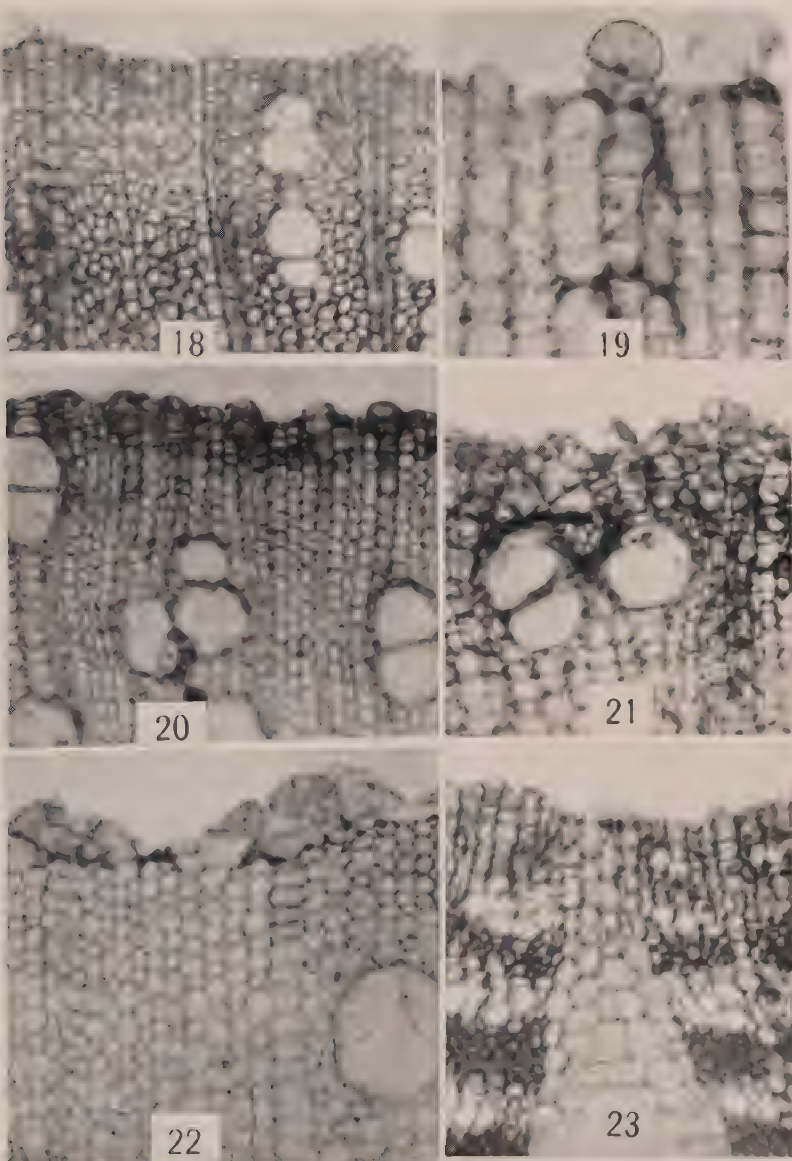

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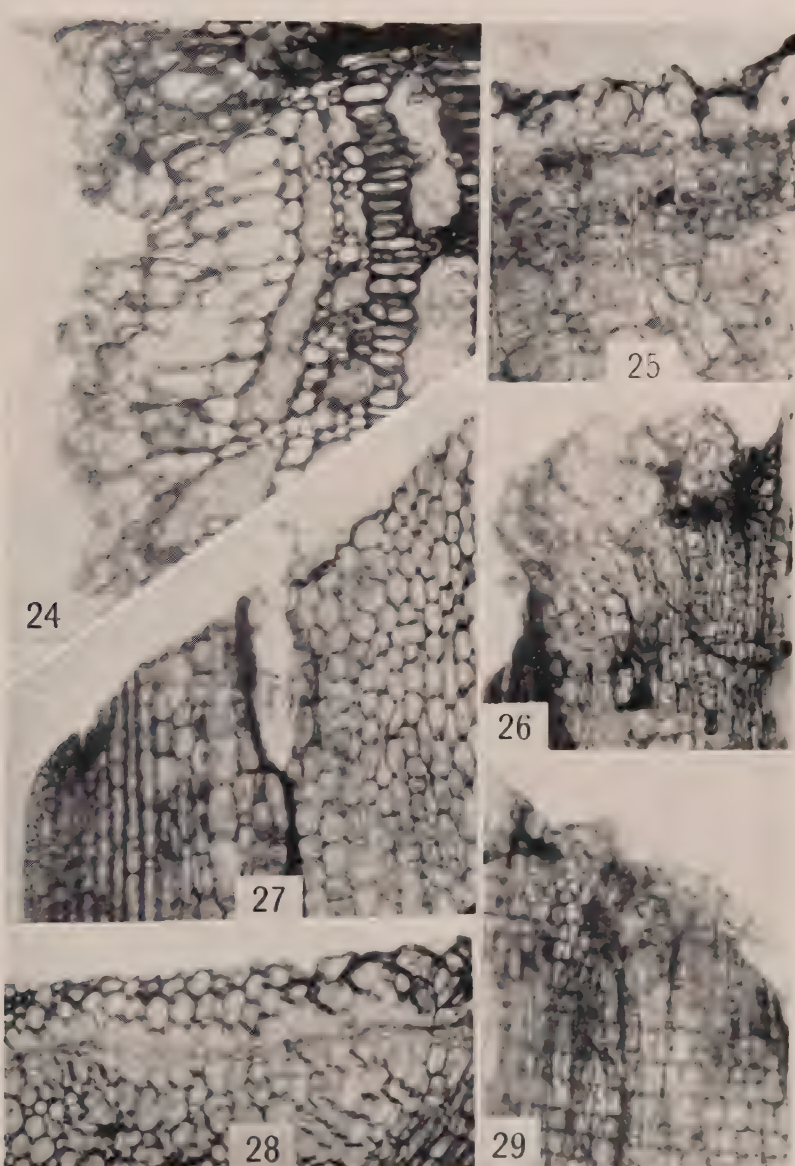
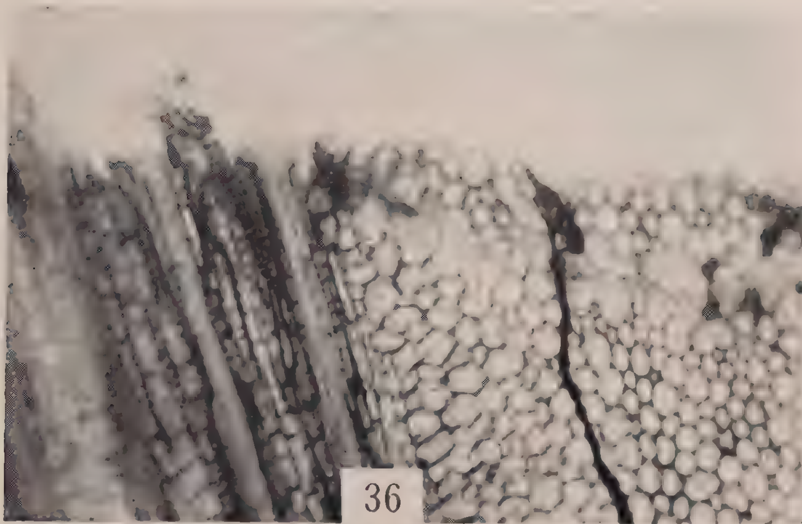


PLATE 6

PLATE 7



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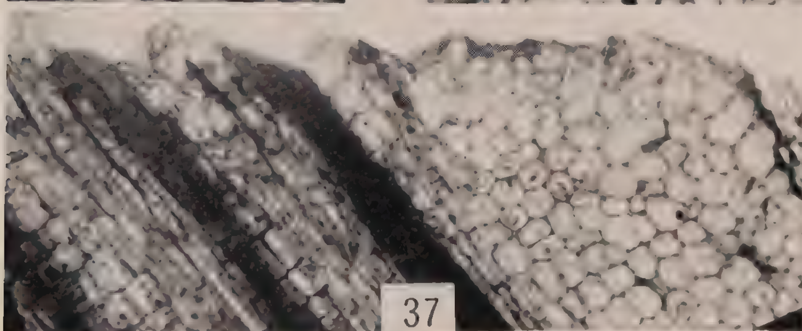

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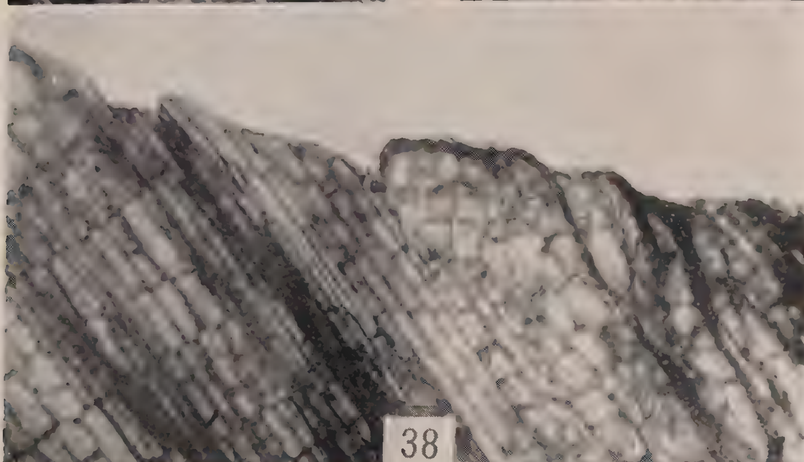

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PLATE 8

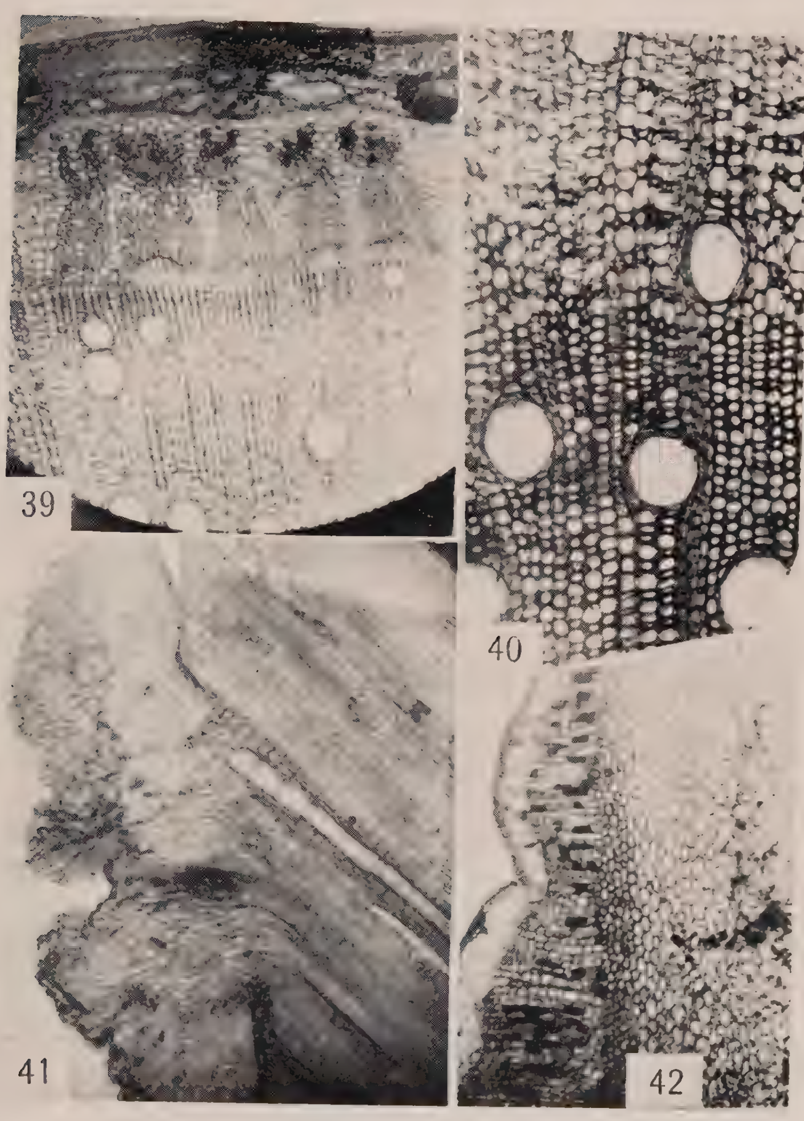
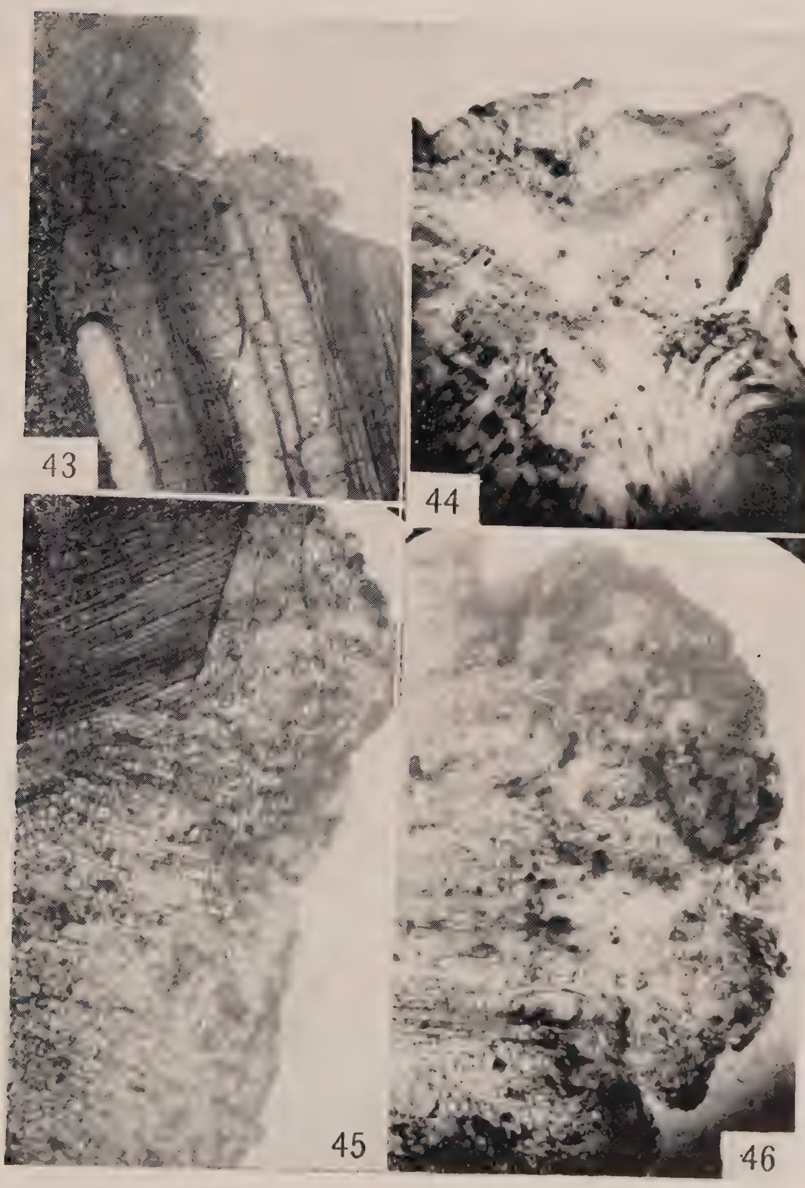


PLATE 9



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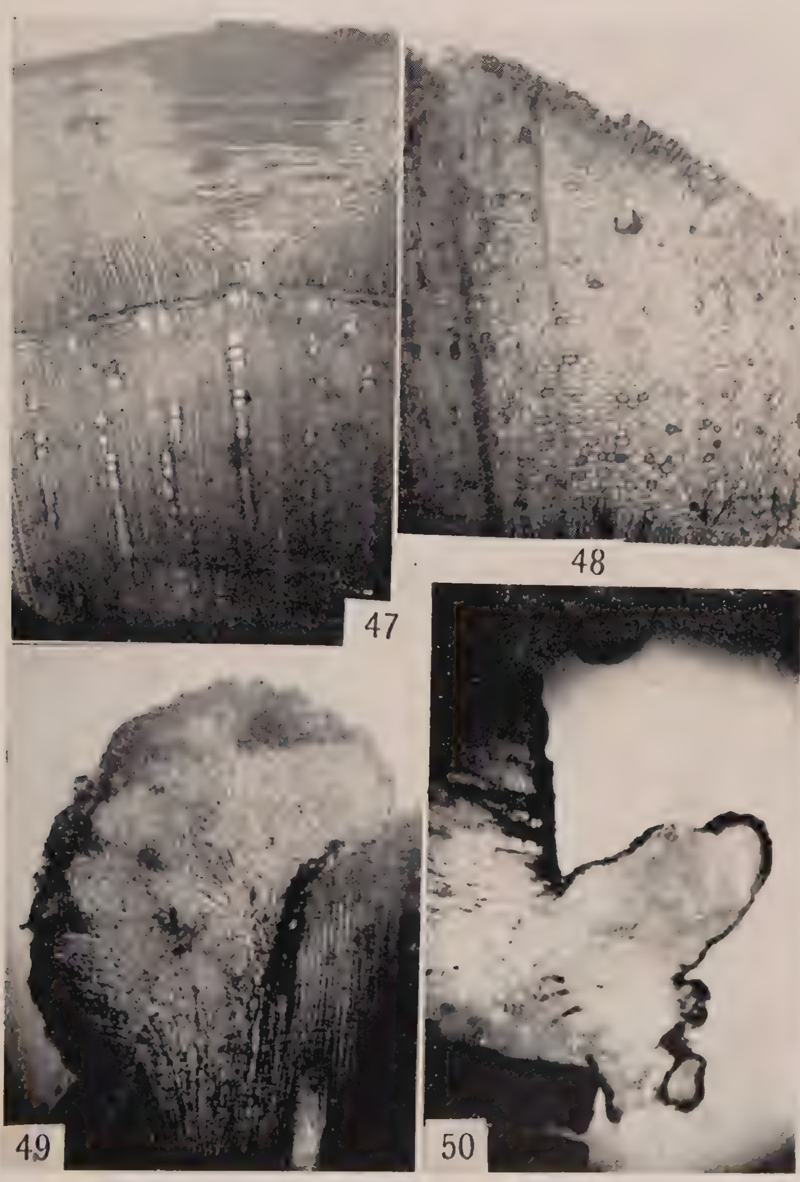

PLATE 11

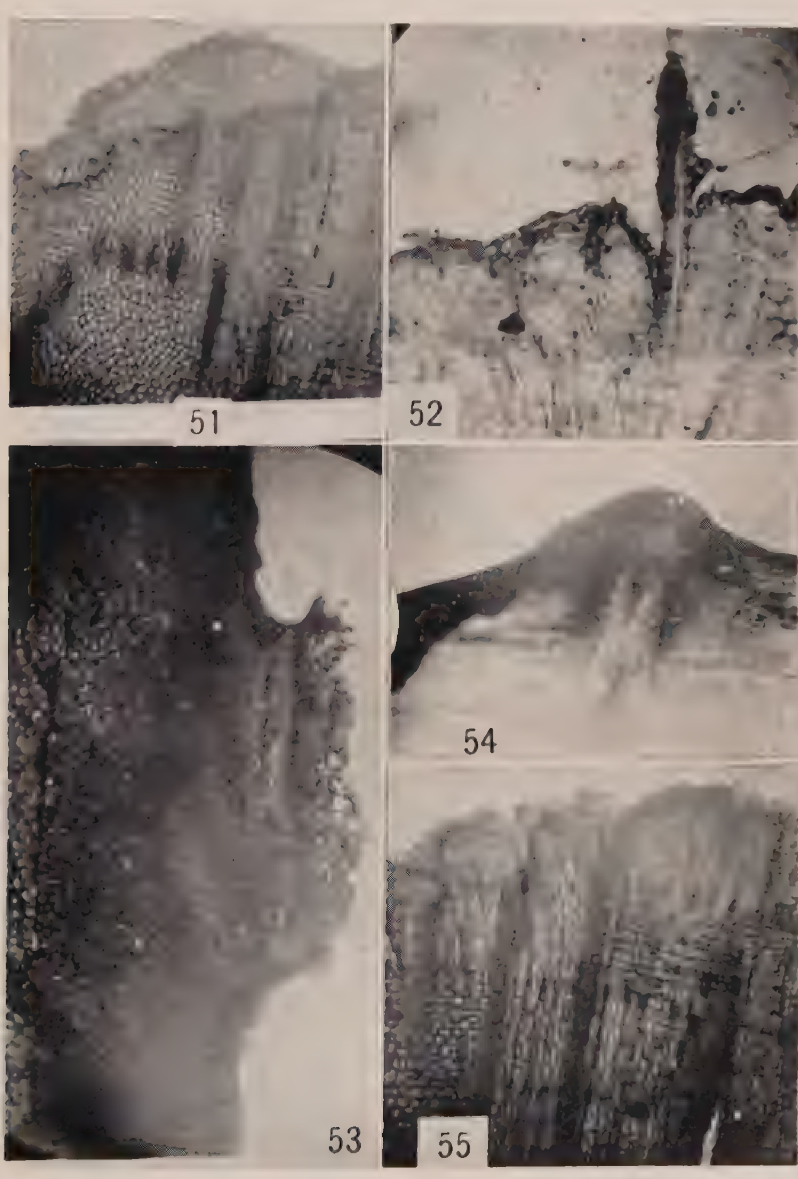

PLATE 12

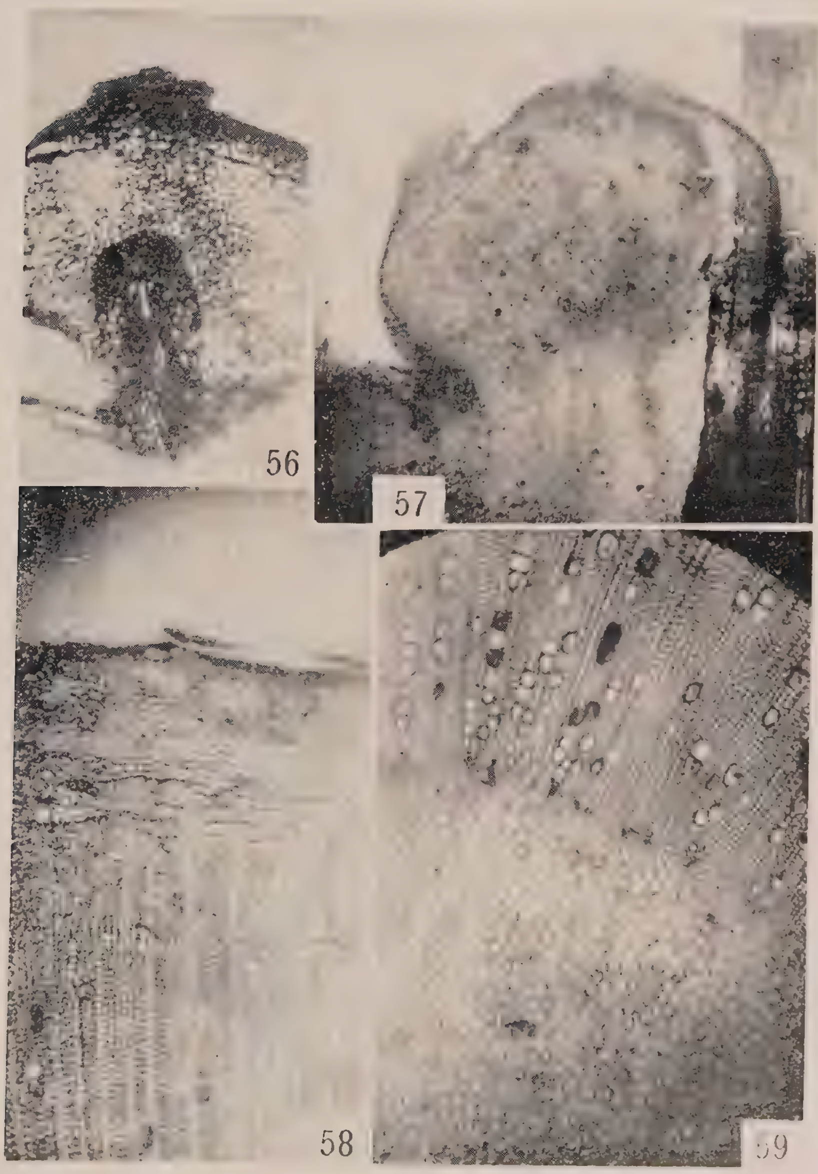

PLATE 13

ABSTRACT

A comparative test of the Ramai, Elon-elon, and Nang Tani varieties of rice. ROBERTO C. DE JESUS. (*Thesis presented for graduation, 1935, with the degree of Bachelor of Agriculture No. 992; Experiment Station contribution No. 1201.*)—With the object of ascertaining how the yield of the Nang Tani variety of rice introduced from Siam would compare with the yields per unit area of the Ramai and the Elon-elon rice varieties, which are considered the two heaviest yielders in this locality, the writer made a comparative test on these three rice varieties.

The seeds used in this study were obtained from the annual farm crops division of the Department of Agronomy. Ten gantas of seed of each of these varieties were cleaned for planting material. The field used was a portion of the lowland rice fields in the College Experiment Station. It had an area of 4,500 square meters. The seeds were sown in the seed beds on July 26, 1934. The seedlings were transplanted on September 9, 1934, at the rate of two to three per hill with a planting distance between hills of 25 cm. Five replications of each variety were made. The plants were given all necessary irrigation, weeding, drainage, and protection from pests. The author made observations in connection with (*a*) germination period, (*b*) behavior of plants in the seed bed, (*c*) height of seedlings at transplanting, (*d*) character of growth of plants in the field, (*e*) flowering period, (*f*) lodging character, (*g*) susceptibility to pests and diseases, and (*h*) yield of each variety.

The Nang Tani variety was harvested on January 14, 1935; the Elon-elon, on January 19, 1935; and the Ramai, on January 23, 1935.

The writer made the following conclusions based on the results of his study:

1. The Elon-elon rice variety germinated within 5 days from the time of sowing, and the Ramai and Nang Tani rice varieties, within 6 days.

2. The average height of Nang Tani seedlings at transplanting was 34.0 ± 0.20 centimeters; Ramai, 33.5 ± 0.29 centimeters; and Elon-elon, the shortest, 28.5 ± 0.14 centimeters.

3. The Ramai plants in the field were more vigorous than either Nang Tani or Elon-elon. The Elon-elon plants were slightly more vigorous than the Nang Tani.

4. The average height of the Ramai rice variety at maturity was 149.0 ± 0.29 centimeters; the Elon-elon, 145.0 ± 0.20 centimeters; and the Nang Tani, 135.0 ± 0.17 centimeters.

5. The Nang Tani rice variety matured earlier than the Ramai and Elon-elon varieties. The Ramai required a longer time to mature than the Elon-elon.

6. With reference to their lodging character, Ramai was found to lodge the most; Nang Tani, next; and Elon-elon, the least.

7. The average number of tillers per hill was 10.14 ± 0.20 for Ramai, 7.94 ± 0.13 for Elon-elon, and 6.58 ± 0.14 for Nang Tani.

8. The Nang Tani variety of rice suffered more from the attack of pests and diseases than either the Ramai or the Elon-elon.

9. From a comparison of the three rice varieties studied, Ramai was the best producer with a yield of 90.84 ± 1.37 cavans per hectare; Elon-elon, second, with a yield of 75.81 ± 3.32 cavans per hectare; and Nang Tani, the poorest, with a yield of 38.02 ± 4.40 cavans per hectare.

—*Abstract by Vicente B. Aragon*

COLLEGE AND ALUMNI NOTES

The enrollment in the College of Agriculture for the second semester, 1937-38, is 445. This number does not include 73 cross-registrants from the School of Forestry, which bring the total up to 518.

The following papers were read at the meeting of the Los Baños Biological Club on October 28:

Mr. Clemente E. Yango. Does corn shelling by machine affect germination?

Mr. Manuel R. Monsalud. A new transplanting tool.

Dr. Manuel L. Roxas, professor of agricultural chemistry emeritus of this College and at present chief of the technical staff of the National Development Company, was the guest of honor at the annual program of the junior class organization on September 25.

Recent promotions among the College alumni in the Bureau of Education: Mr. Pedro Montellano, '15, principal of Central Luzon Agricultural School, Muñoz; Mr. Constancio T. Medrana, '27, principal of Cabagan Farm School, Isabela; and Mr. Santiago T. Medrana, '27, principal of Camarines Sur Agricultural High School, Pili.

Mr. Federico Goseco, '26, entomologist of the Philippine Sugar Association, sailed for Formosa on November 8 for the purpose of collecting and introducing into the Philippines Formosan insects that are known to infest *Aeginetia indica* Linn., a serious root parasite of the sugar cane.

Mr. José C. Miraflores, '15, who is at present a sugar planter in Murcia, Negros Occidental, visited his Alma Mater on September 23 for the first time since his graduation twenty-two years ago.

The American members of the Joint Preparatory Committee on Philippine Affairs and their wives, together with some of the Filipino members, visited the College on September 24.

Foreign visitors to the campus included Muneo Kikuchi, professor of crop science, Hokkaido Imperial University, and Ryunosuke Nagata, professor of forest policy, Tokyo Imperial University, on September 20.

A harvest festival was held by the Department of Agronomy at Higamot Hill in the Experiment Station on October 31. Native games and a literary-musical program in Tagalog, in which College laborers and share tenants participated, featured the day. A large number of faculty members and students attended.

Young mango leaves in many places on the campus were very severely skeletonized by adults of a chrysomelid beetle, *Monolepta bifasciata* Hornst, in the latter part of October, 1937.

[redacted]

Pee Tek Hap, B.S.S.T., '32, formerly chemist of the Government Sugar Central, Tanguerang, Java, and who returned to this College as a special graduate student during the present academic year, died in Manila, a victim of gastric ulcer, on October 30.

A COLLEGE IN TRANSITION

"When the University of Illinois examined the curricula, the qualifications of the professional staff, [and] the general financial and academic standing of the University of the Philippines for purposes of classification, only one college, the College of Agriculture, was ranked 'A'." [1]

Thus, fifteen years ago, did a local writer, who was neither an alumnus nor an employee of the College of Agriculture, state, in an incidental way, but in no uncertain terms, the relative standing of this unit of the University. The action of the University of Illinois was by no means unique; other scientific bodies—all of them foreign—accorded the College of Agriculture a similar favorable acceptance.

A series of more recent events, however, two of which were dealt with in the earlier pages of this journal, has been particularly heartening, owing to the spontaneous expression of appreciation coming this time, not like a vanishing echo from across the ocean, but with the lusty force of neighborly voices. The President of the University of the Philippines, the Government Survey Board, and, above all, His Excellency, the President of the Philippine Commonwealth, each in turn paid this institution highly flattering compliments. What is more, the College of Agriculture, according to proposals under consideration, is at last to be given the opportunity to play an important active part in the shaping and execution of plans for the economic development of the country.

The recognition by the Filipinos themselves of whatever worth their own College of Agriculture may have is most gratifying, not because it satisfies personal vanity, but because it augurs a translation into reality of a desirable ideal in the Philippine government's program of agricultural promotion. The position to which this College has worked itself has not been the fortuitous product of a sudden lucky break. It has been the result of twenty-nine years of hard struggle. Born in 1909, with all the aches and perilous labors of untimely birth, the present College of Agriculture came into being after a hectic series, since 1821, of miscarriages or early deaths

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[1] DURAN, PIO. 1923. Hampering university progress. The Philippines Herald.

of Philippine agricultural colleges. Doubts were not infrequently expressed as to the wisdom of launching into the world this latest offspring, which in some quarters was regarded as a problem child. Near privation because of stinted support and either good-natured derision or active antagonism were to be its lot for many years. On occasions, the College was denounced as "too scientific" and not practical enough; at other times, as giving the students too much practical work at the expense of book learning. The College was blamed for the tendency among its graduates to seek employment where they could engage in activities commensurate with their collegiate training in agriculture, instead of going into dirt farming, as do the graduates of vocational farm schools. In at least two instances, the College was dubbed a "failure" by a Manila newspaper in 1915 and in the halls of the Philippine Legislature in 1924. Ironically enough, in those critical days of this institution, its staunchest defenders were rarely Filipinos; they were mostly American individuals and business organizations. In a measure these disinterested friends have repeatedly saved the College of Agriculture.

Criticisms have a way of affecting this institution. Instead of being resented, such criticisms, originating either internally or from outsiders, have been thankfully welcomed. Not infrequently valuable suggestions for further improvement have come from these sources. This attitude is one of the traditions which the founder of the College of Agriculture, Dean Edwin Bingham Copeland, and his immediate successor, the late Dean Charles Fuller Baker, taught our generation. That, in addition, of course, to working, not in pursuit of any vague principle like "upholding the dignity of labor," but because the worker is interested in what he is doing and because of a conviction that he has a satisfying mission to perform. Thus it is that research could be carried on outside of office hours without the researcher feeling that he thereby makes of himself a self-sacrificing martyr to science. That experiment station work could be carried on in this College with no appropriation other than the sum granted but once, in 1918, by the Philippine Legislature exclusively for the purchase of lands, was largely the result of this prevailing spirit.

All these traditions might now have been lost and forgotten had it not been for the farsightedness of the early American faculty of the College of Agriculture when from the beginning they systematically trained deserving Filipinos to take their places as they left the service. In this way an unbroken continuity has been assured, because the basic supply has not been dependent on the uncertain

source of imported personnel. This policy was, in fact, of unusual significance because it was unparalleled in the annals of either Spanish or American colonial administration of the Philippines, where the rule, especially in government bureaus, had hitherto apparently been to close the more responsible technical positions to the natives. The deanship and the entire technical staff of the College of Agriculture have now been composed of Filipinos for some ten years. A sizable proportion of its faculty members has included Filipinos since our early beginnings. Filipinization has been brought about, not through a violent dislocation, but as a result of gradual evolutionary growth.

The recent drift of events with respect to the College of Agriculture recalls the prophetic words written about it by E. E. Elser in 1924: "Some things in the life of any virile institution can await the fortunes of time." [2] The changed conditions are an occasion for self-congratulation only in that this business of coming of age carries with it weightier problems and greater responsibility for the College. In a way, one is inclined to feel somewhat apprehensive lest these changes might perchance usher in a transition from the vigorous growth of a young institution to the stagnation and eventual decay that trail after adult life.

[2] ELSER, E. E. 1924. Our College of Agriculture. American Chamber of Commerce Journal, October, 1924, p. 5–6.

Courtesy Signal Corps, Philippine Army.

Boy Scouts in Loyalty Day parade, College of Agriculture, 1937

THE PROXIMATE PHYSICAL AND CHEMICAL COMPOSITION OF TWENTY-SIX SPECIES OF CITRUS AND TWELVE NON-CITRUS FRUITS GROWN IN THE PHILIPPINES [1]

ALFREDO C. CABBAB AND F. A. SOLIVEN
Of the Department of Agricultural Chemistry

The physical and chemical analyses of some of the fruits found growing in the Philippines are important in determining their relative values as part of the diet and as sources of raw materials for other industries; hence, this work was undertaken.

There are a few investigators who have reported on the proximate chemical composition of Philippine fruits.

Gibbs and Agcaoili (1912) made a chemical study of the most important varieties of citrus found in the Philippines. The pertinent parts of their results are embodied in table 1. The other investigators who worked on the proximate chemical analyses of fruits were Pratt and del Rosario (1913), Salvador (1912), Adriano (1925), Santos and Adriano (1928), Manabat (1930), Valenzuela and Wester (1930), Nuestro (1930), and Santos and Ascalon (1931). Table 1 shows the results of their analyses of some of the fruits used in their studies.

Wells and his co-workers (1925) analyzed the juice of some citrus fruits for their total solids, sucrose, reducing sugar, and citric acid. They found that the Pink pummelos were the heaviest (695 grams). The grapefruits weighed between 400 grams and 500 grams. The oranges came third, the range being from 104 to 394.9 grams. They also found that among the oranges the Boone orange has the highest percentage of juice, 56.05 per cent, while the other fruits ranged from 31 per cent up. The specific gravity of the juice lies between 1.028 and 1.042. It was also found that the amount of seeds ranged from 0.08 per cent in Tahiti lime to 6.60 per cent in biasong. When the composition of the juice was determined, they found:

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[1] Experiment Station contribution No. 1202. The data used in this paper is a part of the thesis presented by the senior author in 1937 for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture.

(1) Sucrose ranged from an insignificant value in Tahiti lime, Everglade lime, and lemon, to 4.85 per cent in the case of *Citrus mandurensis*.

(2) Reducing sugar ranged from an insignificant value in lombog to 4.50 per cent in camisan.

(3) Citric acid ranged from 0.154 per cent in Pink pomelo to 3.94 per cent in Everglade lime. It must be noted in this connection, however, that the amount of citric acid was calculated from the volume of N/10 alkali required to titrate the acid in a given weight of juice. This does not only represent citric acid but also the other kinds of acid such as oxalic, malic, and tartaric. They further observed that citrus fruits high in sugars have very low citric acid content. This result was in accord with the findings of Gibbs and Agcaoili (1912).

MATERIALS AND METHODS

Materials

In the gathering of the materials, care was exercised that only mature fruits were used. The names, both dialect and scientific, of most materials used were obtained from Merrill, E. D. "An enumeration of Philippine flowering plants" and from Hume, H. H. "The cultivation of citrus fruits."

Citrus. Collected from Tanauan Citrus Station, Tanauan, Batangas.

1. Cajel (strain No. 1) (Tagalog, Bicol, Visayan), *Citrus sinensis* Osbeck.
2. Sour orange, *Citrus aurantium* Linn.
3. Chinese mandarin, *Citrus nobilis* Lour.
4. King orange, *Citrus nobilis Lour.*
5. Kishiu, *Citrus nobilis* Lour.
6. Saagkam mandarin, *Citrus nobilis* Lour.
7. Satsuma, *Citrus nobilis* Lour. var. *unshiu*
8. Batangas mandarin; sintones (Tagalog), naranjita (Spanish), ransas (Bicol), daranjita (Ilocano), *Citrus nobilis* Lour. var. *deliciosa* Swingle.
9. Szinkom, *Citrus nobilis* Lour.
10. Tizon, *Citrus nobilis* Lour.
11. Cajel (strain No. 2) (Tagalog), *Citrus sinensis* Osbeck.
12. Saigon orange, *Citrus sinensis* Osbeck.
13. Lime (strain No. 1); dayap (Tagalog), dalayap (Ilocano),

sua (Bicol), limon (Spanish), *Citrus aurantifolia* Swingle.

14. Lime (strain No. 2); dayap (Tagalog), dalayap (Ilocano), sua (Bicol), limon (Spanish), *Citrus aurantifolia* Swingle.

15. Kusaie lime, *Citrus aurantifolia* Swingle.

16. Tahiti lime, *Citrus aurantifolia* Swingle.

17. Panuban; suha (Tagalog, Bicol, Ilocano), *Citrus maxima* Merr. var. *panuban* (Wester).

18. Ellen pummelo, *Citrus maxima* Merr.

19. Pomelo or grapefruit, *Citrus maxima* Merr. (var. not determined)

20. Pummelo (native); shaddock (English), suha (Tagalog), lukban (Tagalog, Bicol, Ilocano), *Citrus maxima* Merr.

21. Siamese pummelo, *Citrus maxima* Merr.

22. "Vermillion" pummelo, *Citrus maxima* Merr.

23. Calamondin (Tagalog), *Citrus mitis* Blanco.

24. Calamandarin, Citrus hybrid (*Citrus mitis* Blanco × *Citrus nobilis* Lour. var. *deliciosa* Swingle).

25. Kulubot (Tagalog, Visayan, Bicol), kamulau (Ilocano), *Citrus hystrix* D.C. var. *torosa* (Blanco) Wester.

26. Tangelo, Citrus hybrid (*Citrus nobilis* Lour. var. *deliciosa* Swingle × *Citrus grandis* Osbeck).

Other fruits

27. Santol, santor (most Philippine languages), *Sandoricum koetjape* (Burm. f.) Merr.

28. Pineapple; piña (Sp.), *Ananas comosus* (Linn.) Merr. var. Smooth Cayenne.

29. Mango, manga (Tagalog, Ilocano), *Mangifera indica* Linn. var. Carabao.

30. *Lanzones* (Tagalog, Bicol), bukas (Visayan), *Lansium domesticum* Correa.

31. Sinigüelas (Tagalog), siriguelas (Bicol), sarguelas (Ilocano), *Spondias purpurea* Linn.

32. Duhat (Tagalog), duat (Pampango), lomboi (Ilocano), *Eugenia cumini* (Linn.) Druce.

33. Guava; bayabas (Tagalog, Ilocano, Visayan), bayauas (Bicol), *Psidium guajava* Linn.

34. Guanabano (Tagalog), bayubana (Ilocano), ilabanos (Visayan), *Anona muricata* Linn.

35. Camias (Tagalog), *Averrhoa bilimbi* Linn.

36. Ates, atis, yates (Spanish-Filipino), *Anona squamosa* Linn.

37. Papaya (Spanish), tapayas (Bicol), papaya (Visayan, Ilocano, Tagalog), *Carica papaya* Linn.

38. Watermelon; pakuan (Tagalog), sandia (Spanish), tinum (Sulu), *Citrullus vulgaris* (Linn.) Schrad.

The fruits used in this experiment were collected mostly from the Tanauan Citrus Station, Bureau of Plant Industry, located in the province of Batangas. The other samples were obtained from the markets of nearby towns of Laguna and in the neighborhood of the College Campus.

Methods of analysis

Physical composition of samples. (1) *Weight.* The fruits were selected at random. Then the weights of at least half a dozen, when specimens were rare, to a dozen, when fruits were abundant, were determined and the average weight taken and reported.

(2) *Refuse and edible portion.* The percentage of edible portion was obtained by weighing the whole fruit, removing all refuse parts, and then weighing the edible portion. From the weight of the edible portion and weight of the original fruit, the percentage of the edible portion was calculated.

(3) *Seeds.* The percentage of seeds was determined in like manner. The weight of the seeds was first obtained and then the percentage was calculated from the weight of the original fruit.

(4) *Volume of juice.* Some of the fruits analyzed contained much juice. In this case the volume of juice obtainable from each fruit was determined. For this purpose a laboratory Carver hydraulic press was used.

(5) *Specific gravity of juice.* The specific gravity of the juice was determined by means of a Mohr-Westphal balance.

Chemical composition of the edible portion

The percentages of the constituents reported were all based on the edible portions of the materials under study. Quadruplicate samples were used in all determinations.

The methods of analyses followed were those given by the Association of Official Agricultural Chemists with the exception of the determination of total sugars and reducing sugar. The sugars were determined in accordance with the method of Browne (1912).

RESULTS

The proximate physical composition of the citrus fruits studied is given in table 2; that of the non-citrus fruits, in table 2a.

Table 3 shows the proximate chemical composition of the citrus fruits analyzed and table 3a, of the non-citrus fruits.

For purposes of ready comparison, the analyses of fruits similar to those studied in this work reported by Gibbs and Agcaoili (1912), Pratt and del Rosario (1913), Wells et al. (1935), and Santos and Ascalon (1931) are incorporated in this work and are reproduced in table 1.

In this study 26 species of citrus and 12 non-citrus fruits were analyzed for the average weight of the fruit, amount of refuse, edible portion, seeds, juice; and for the moisture, ash, protein, total sugars, water soluble sugars, sucrose, pH, and titratable acidity of the edible portion.

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TABLE 1

Analyses of fruits (Gibbs and Agcaoili, 1912; Pratt and Rosario, 1913; Wells et al, 1925; and Santos and Ascalon, 1931)

NAME OF FRUIT	WT. OF FRUIT	EDIBLE PORTION		SEEDS		REFUSE		MOISTURE		ASH		PROTEIN		TOTAL SUGAR	REDUCING SUGAR	SUCROSE
	grams	*grams*	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*per cent*	*per cent*	*per cent*
1. Ates [1]	195	114	—	—	—	81	—	87	—	1.0	—	2.0	—	—	—	—
[3]	240	52	—	—	6	—	42.0	—	—	—	0.97	—	1.12	16.0	15.77	0.23
2. Camias [1]	10	10	—	—	—	—	—	9.4	—	0.04	—	—	0.59	—	—	—
[3]	16	—	—	—	—	—	—	—	—	—	0.40	0.08	6.61	—	2.21	0.00
3. Siniguelas [1]	22	13	—	—	—	9	—	9.9	—	12.0	—	—	—	—	—	—
[3]	20	50	—	—	23	—	27.0	—	—	—	0.27	—	0.63	—	—	—
4. Duhat [1]	4	3	—	—	—	1	—	2.42	—	0.02	—	0.02	—	6.14	5.97	—
[3]	4	—	75	—	25	—	—	—	—	—	0.7	—	0.81	12.70	12.70	0.00
5. Guanabano [1]	568	392	—	—	—	176	—	303.0	—	—	3.0	—	1.0	—	—	—
[3]	650	69	—	—	8	—	23.0	—	—	—	0.85	0.38	0.38	—	—	—
6. Guava [1]	45	45	—	—	—	—	—	36.74	—	0.03	—	0.43	—	—	—	—
[3]	45	—	83	—	17	—	24.2	—	—	—	0.71	—	1.38	7.54	3.22	—
7. Lanzones [1]	22	13	—	—	—	9	—	11.26	—	6.08	—	0.10	—	—	—	—
[3]	20	—	80	—	6	—	14.0	—	—	—	0.59	—	1.13	8.10	4.90	—
8. Mango [1]	240	177	—	—	—	63	—	145.0	—	1.0	—	6.0	—	—	—	—
9. Papaya [1]	1000	672	—	—	—	328	—	593.0	—	6.0	—	5.0	—	—	—	—
10. Pineapple [1]	820	410	—	—	—	410	—	355.0	—	1.0	—	2.0	—	—	—	—
[3]	800	—	50	—	—	—	—	—	—	—	0.38	—	0.44	9.41	3.36	—
11. Santol [1]	93	61	—	—	—	32	—	51.0	—	1.0	—	1.0	—	—	—	—
[3]	85	—	70	—	5	—	25.0	—	—	—	0.98	—	0.86	4.89	3.08	1.66
12. Watermelon [1]	1000	510	—	—	—	490	490.0	466.0	—	0.92	—	3.10	—	—	—	—
[3]	2250	—	51	—	4	—	45.0	—	—	—	0.18	—	0.60	7.04	5.73	1.23
13. Pummelo [1]	895	546	—	—	—	349	—	479.0	—	3.00	—	4.00	—	—	—	—
[3]	930	—	61	—	5	—	34.0	—	—	—	0.63	—	0.66	—	2.56	—
14. Cajel [1]	127	73	53	—	—	—	—	67.90	—	0.27	—	0.29	—	—	—	—
[4]	—	—	—	—	—	—	—	—	—	—	0.45	—	0.57	—	2.47	3.03
15. Calamondin [1]	16	9	—	—	—	7	—	6.28	—	0.04	—	trace	—	—	—	—
16. Narangita [1]	118	64	—	—	—	54	—	—	—	—	—	—	—	—	—	—
[4]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17. Sour orange [2]	384	—	—	—	—	152.3	39.55	—	—	—	—	—	—	—	—	—
18. Pummelo or grapefruit [2]	460.5	—	—	—	—	141.5	30.64	—	—	—	—	—	—	—	—	—
19. Ellen pummelo [2]	322.5	—	—	—	—	83.0	25.73	—	—	—	—	—	—	—	—	—
20. Tahiti lime [2]	120.1	—	—	—	—	36.1	30.02	—	—	—	—	—	—	—	—	—

[1] Santos and Ascalon (1931).
[2] Wells et al (1925).
[3] Pratt and Rosario (1913).
[4] Gibbs and Agcaoili (1912).

TABLE 2

Average physical composition of different species of citrus

NAME OF FRUIT	WT. OF FRUIT	REFUSE		EDIBLE PORTION		SEEDS		JUICE		
	grams	*grams*	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*vol. mls.*	*sp. gr.*	*per cent*
1. Cajel (strain 1), *Citrus sinensis* Osb.	120.50	35.90	29.79	73.40	60.91	1.21	0.99	18.30	1.0290	15.36
2. Chinese mandarin, *Citrus nobilis* Lour.	208.50	114.60	54.96	88.60	42.49	5.30	2.54	45.30	1.0274	22.32
3. Cajel (strain 2), *Citrus sinensis* Osb.	126.00	42.30	35.10	76.50	63.40	3.10	2.57	40.10	1.0290	34.24
4. Lime (strain 1), *Citrus aurantifolia* Swingle	69.34	20.46	29.50	42.64	61.49	6.24	8.99	34.40	1.0312	49.67
5. Ellen pummelo, *Citrus maxima* Merr.	481.72	218.50	45.36	250.00	51.90	12.20	2.53	105.50	1.0264	22.47
6. Calamandarin, *Citrus* hybrid	71.42	19.26	26.96	47.84	66.98	4.32	6.04	44.60	1.0294	64.28
7. Calamondin, *Citrus mitis* Blanco	69.50	29.30	42.16	36.77	52.90	3.43	4.94	27.30	1.0301	40.46
8. King orange, *Citrus nobilis* Lour.	436.20	209.40	48.01	221.50	50.77	5.30	1.21	90.30	1.0330	21.38
9. Kishiu, *Citrus nobilis* Lour.	108.30	23.40	21.16	81.50	75.25	3.40	3.14	36.00	1.0260	34.10
10. Kulubot, *Citrus hystrix* DC.	64.30	22.90	36.39	28.82	44.82	5.42	1.43	26.00	1.0308	41.68
11. Kusaie lime, *Citrus aurantifolia* Swingle	60.10	28.30	47.08	30.30	50.41	1.50	2.49	15.30	1.0310	26.24
12. Lime (strain 2), *Citrus aurantifolia* Swingle	80.60	36.30	45.04	37.90	47.02	6.40	4.94	32.00	1.0230	40.81
13. Pummelo, or grapefruit, *Citrus maxima* Merr.	453.40	212.30	36.82	227.50	50.17	13.60	2.99	102.60	1.0230	23.15
14. Panuban, *Citrus maxima* Merr.	904.80	244.70	27.04	651.00	71.94	8.22	0.91	210.10	1.0290	23.89
15. Pummelo (Native), *Citrus maxima* Merr.	1003.50	250.30	24.94	743.50	74.09	10.34	1.03	224.60	1.0206	22.84
16. Saagkam, *Citrus nobilis* Lour.	203.40	70.30	34.56	128.88	63.35	4.22	2.07	36.20	1.0220	18.19
17. Saigon orange, *Citrus maxima* Merr.	1225.00	673.64	54.99	540.86	44.15	10.50	0.86	270.00	1.0200	22.49
18. Satsuman, *Citrus nobilis* Lour. var Unshiu	180.00	91.36	50.75	85.04	47.24	3.60	2.00	35.60	1.0380	20.52
19. Sintonis, *Citrus nobilis* Lour.	116.02	40.62	35.01	72.46	62.45	2.94	2.53	37.10	1.0307	32.95
20. Siamese pummelo, *Citrus maxima* Merr.	865.20	203.50	23.52	647.00	74.78	4.20	0.49	223.40	1.0140	26.18
21. Sour orange, *Citrus aurantium* Linn.	508.30	236.40	46.50	251.60	49.44	20.30	3.99	126.05	1.0324	25.60
22. Szinkom, *Citrus nobilis* Lour.	102.00	20.14	19.74	79.85	78.28	2.01	1.97	32.30	1.0230	32.39
23. Tahiti lime, *Citrus aurantifolia* Swingle	107.30	50.20	46.78	56.60	52.74	0.50	0.46	26.90	1.0270	20.14
24. Tangelo, *Citrus* hybrid	231.44	75.00	32.41	150.00	64.81	5.92	2.56	52.60	1.0276	23.35
25. Tizon, *Citrus nobilis* Lour.	177.40	68.30	38.50	105.10	59.24	4.00	2.25	32.30	1.0420	19.30
26. Vermillion, *Citrus maxima* Merr.	1560.00	830.60	53.24	716.20	45.91	13.20	0.84	210.00	1.0184	20.24

TABLE 2a

Average physical composition of some non-citrus Philippine fruits

NAME OF FRUIT	WT. OF FRUIT	REFUSE		EDIBLE PORTION		SEEDS		JUICE		
	grams	*grams*	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*vol. ml.*	*sp. gr.*	*per cent*
1. Ates, *Anona squamosa* Linn.	254.56	92.91	36.50	156.30	61.40	5.85	2.30	48.36	1.0610	20.16
2. Camias, *Averrhoa bilimbi* Linn.	18.60	.	—	18.60	100.00	.	—	8.42	1.0220	42.16
3. Sinigüelas, *Spondias purpurea* Linn.	20.41	0.38	3.77	15.32	75.60	4.18	20.63	3.78	1.0760	19.92
4. Duhat, *Eugenia cumini* (Linn.) Druce	7.23	1.69	23.42	5.37	74.30	0.16	2.28	1.89	1.0920	27.20
5. Guanabano, *Anona muricata* Linn.	753.00	253.08	33.61	498.49	66.20	1.43	0.19	124.60	1.0550	5.18
6. Guava, *Psidium guajava* Linn.	33.40	—	—	33.40	100.00			3.61	1.0740	11.57
7. Lanzones, *Lansium domesticum* Correa	24.30	8.74	26.00	15.13	62.30	0.41	1.70	5.10	1.0490	21.19
8. Mango, *Mangifera indica* Linn.	163.50	44.50	27.00	114.45	70.00	3.76	2.31	17.30	1.0830	11.32
9. Papaya, *Carica papaya* Linn.	1534.00	466.79	30.43	1064.12	69.35	3.37	0.22	183.64	1.0250	12.97
10. Pineapple, *Ananas comosus* (Linn.) Merr.	1660.00	554.93	33.43	1090.95	65.72	—	—	301.00	1.0610	19.23
11. Santol, *Sandoricum koetjape* (Burm. f.) Merr.	124.30	55.80	44.89	66.10	53.18	3.40	1.93	19.00	1.0402	15.90
12. Watermelon, *Citrullus vulgaris* (Linn.) Schrad.	2035.20	973.23	47.82	1037.54	50.98	24.42	1.20	372.13	1.0130	13.93

TABLE 3

Moisture, ash, protein, total sugars, water soluble reducing sugar, sucrose, and acidity content of citrus fruits

NAME OF FRUIT	MOISTURE	ASH		PROTEIN		TOTAL SUGARS		WATER SOLUBLE SUGAR		SUCROSE	pH	TITRATABLE ACIDITY OF N/10 NaOH PER 100
		Fresh basis	Dry basis	Fresh basis	Dry basis	Fresh basis	Dry basis	Fresh basis	Dry basis			
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*		*mls.*
1. Cajel (strain 1)	91.23	0.052	0.60	0.034	0.41	0.379	4.32	0.376	4.29	0.03	3.20	816.41
2. Chinese mandarin	89.26	0.039	0.37	0.060	0.56	0.342	3.18	0.273	2.54	0.61	3.62	456.37
3. Cajel (strain 2)	89.12	0.048	0.45	0.059	0.54	0.496	4.56	0.476	4.38	0.06	4.55	350.36
4. Lime (strain 1)	92.94	0.035	0.43	0.039	0.48	0.055	0.68	0.051	0.63	0.26	3.14	720.60
5. Ellen pummelo	91.27	0 044	0.50	0 042	0.48	0 358	4.10	0.334	3.82	0.22	4.39	379.43
6. Calamandarin	89.71	0.047	0.46	0.056	0.53	0.149	1.45	0.125	1.22	0.45	3.50	536.13
7. Calamondin	91.99	0.036	0.45	0.043	0.53	0.211	2.63	0.173	2.16	0.34	2.97	1140.36
8. King orange	90.73	0.037	0.40	0.049	0.52	0.318	3.95	0.298	3.71	0.38	4.51	350.11
9. Kishiu	91.95	0.031	0.31	0.038	0.47	0.345	3.72	0.311	3.35	0.23	4.63	361.94
10. Kulubot	91.58	0.050	0.59	0 041	0.49	0.154	1.83	0.120	1.42	0.18	3.23	861.60
11. Kusaie lime	90.50	0.049	0.52	0 064	0.67	0.152	1.62	0.134	1.44	0.09	3.03	641.97
12. Lime (strain 2)	89.54	0.041	0.40	0 074	0.71	0.151	1.47	0.143	1.37	0.12	3.37	839.50
13. Pummelo or grapefruit	91.95	0.044	0.55	0.038	0.47	0.267	3.28	0.256	3.14	0.12	4.37	135.18
14. Panuban	90.03	0.047	0.48	0 047	0.47	0.365	3.66	0.344	3.45	0.20	4.62	103.43
15. Pummelo (native)	89.74	0.042	0.41	0.074	0.72	0.540	5.26	0.412	4.02	1.19	4.38	194.23
16. Saagkam	88.66	0.043	0.42	0.061	0.54	0.253	2.23	0.235	2.07	1.15	4.17	333.62
17. Saigon orange	89.32	0.052	0.49	0.049	0.46	0.367	3.44	0.238	2.21	1.16	4.42	96.52
18. Satsuma	89.50	0.038	0.37	0.050	0.47	0.310	2.95	0.297	2.83	0.12	4.41	390.98
19. Sintonis	91.76	0.049	0.60	0.043	0.52	0.382	4.63	0.358	4.34	0.29	4.54	345.29
20. Siamese pummelo	90.83	0.041	0.45	0.044	0.48	0.334	3.64	0.310	3.38	0.25	4.75	121.36
21. Sour orange	88.10	0.065	0.55	0.052	0.44	0.182	1.53	0.154	1.29	0.22	2.78	737.36
22. Szinkom	90.88	0.044	0.48	0.041	0.46	0.360	3.95	0.338	3.71	0.23	4.45	411.31
23. Tahiti lime	88.05	0.034	0.37	0.054	0.45	0.186	1.56	0.157	1.31	0.21	3.50	536.13
24. Tangelo	91.66	0.040	0.48	0.041	0.49	0.274	3.28	0.264	3.17	0.11	4.13	407.94
25. Tizon	90.29	0.041	0.43	0.056	0.58	0.382	3.94	0.337	3.47	0.45	4.60	393.64
26. Vermillion	90.81	0.037	0.40	0.046	0.51	0.215	2.34	0.195	2.12	0.21	4.43	96.31

TABLE 3a

Moisture, ash, protein, total sugars, water soluble sugar, sucrose, and acidity content of non-citrus Philippine fruits

NAME OF FRUIT	MOISTURE	ASH		PROTEIN		TOTAL SUGARS		WATER SOLUBLE SUGAR		SUCROSE	pH	TITRATABLE ACIDITY Ml. N/10 NaOH PER 100 GMS.
		Fresh basis	Dry basis	Fresh basis	Dry basis	Fresh basis	Dry basis	Fresh basis	Dry basis			
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*		
1. Ates	87.72	0.150	1.24	0.069	0.56	1.365	11.12	1.296	10.55	0.54	5.36	156.63
2. Camias	93.11	0.048	0.70	0.063	0.92	0.186	2.71	0.171	2.47	0.22	4.47	140.20
3. Sinigüelas	86.98	0.210	1.59	0.096	0.74	1.256	9.65	1.188	9.13	0.48	5.45	56.17
4. Duhat	80.71	0.098	0.51	0.212	1.10	2.263	11.73	2.201	11.41	0.30	4.80	126.36
5. Guanabano	82.36	0.231	1.31	0.095	0.54	2.048	11.61	1.988	11.27	0.33	5.15	102.33
6. Guava	76.90	0.401	1.74	0.365	1.58	1.271	5.50	1.139	4.93	0.53	5.40	93.30
7. Lanzones	87.73	0.061	0.58	0.131	1.07	0.681	5.55	0.617	5.03	0.49	4.14	267.31
8. Mango	79.77	0.101	0.50	0.107	0.53	1.052	5.20	0.975	4.82	0.35	5.41	32.10
9. Papaya	87.51	0.103	0.83	0.101	0.81	0.990	7.93	0.945	7.57	0.34	5.88	21.36
10. Pineapple	87.82	0.062	0.51	0.065	0.53	0.523	4.29	0.462	3.79	0.42	4.61	92.33
11. Santol	83.48	0.206	1.25	0.083	0.50	0.702	4.25	0.623	3.27	0.46	4.57	301.67
12. Watermelon	90.83	0.017	0.18	0.052	0.57	0.570	6.21	0.457	4.99	1.16	6.14	26.32

EFFECTS OF APPLICATION OF VARYING QUANTITIES OF LIME UPON THE YIELD OF CANE AND SUGAR [1]

DEMETRIO G. MIRANDA

In the Philippines little is known about the effects of lime on sugar-cane fields. Arancillo (1934), in his recent study on the effects of the application of different amounts of lime upon the yields of cane and sugar in the College of Agriculture, found that two and one-half tons of lime to a hectare gave a high gain. The minimum and maximum amounts of lime that will give profit, however, has not been studied.

Many publications on the use of lime on sugar cane and its immediate effects have been published.

Mirasol (1918) found that the application of 1000 kilograms of lime per hectare gave an increase in yield of cane and sugar that more than paid for the cost of lime and its application.

Reynoso, cited by Deerr (1921), wrote in the middle of the last century:

> "Experience has shown that lime is a necessary element in the constitution of soils most appropriate to the cane; in calcareous soils not only are the most robust canes grown, but these also afford juices richest in sugar from which is easily extracted the desired product. These are both of great return and very sacchariferous, but it must not be forgotten that lime is but one element which associated with others forms good soil."

Pritchett (1924) found that plots treated with crushed limestone-shell fertilizer gave 20.44 per cent cane and 23.5 per cent sugar more than the control plots. In the same year, Pritchett found that the application of lime to the soil planted with the cane of the Negros Purple variety gave 19.21 per cent more cane and 13.62 per cent more sugar than the control. The same investigator (1925) working on the application of lime to the soils of Ma-ao district, Negros Occidental, obtained an increase in the lime plots of 13.6 per cent cane and 13.8 per cent sugar per hectare. He reported that previous results obtained from fields which received lime-shell treatment were

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[1] Thesis presented for graduation, 1937, with the degree of Bachelor of Science in Agriculture from the College of Agriculture; Experiment Station contribution No. 1203. Prepared in the Department of Agronomy under the direction of Dr. Valeriano C. Calma.

so uniformly encouraging as to lead to the belief that its more general use would result in profitable returns and in the physical improvement of the soils on which it had been applied. In 1926 he studied the effects of lime on a heavy clay soil and found that the lime-treated plots gave 4.32 tons of cane, or 11.6 per cent, and 13.42 piculs of sugar, or 15.4 per cent, more than the control.

Arrhenius, cited by Van Harreveld-Lake (1928), working on the correlation between reaction number and sugar yields of the soil of Java, found with cane 6.5 months and 5 months old that the highest yield of cane was obtained at pH 7.0. The yield of stalks was lowered with both a higher and lower reaction number. The same author stated that probably the highest production of sugar would be obtained with an approximately neutral reaction.

Lee (1929) reported that an application of two tons of limestone shells per hectare gave an increase in yield of 17.22 piculs of sugar. He stated further that this was a very profitable increase, inasmuch as limestone shell is a very cheap material. It was found, however, that, whereas the limestone shell increased the quality ratio, larger amounts than two tons lowered the yield of sugar. He stated that the application of two metric tons of lime material per hectare was almost certain to give a profitable increase in yield of cane and sugar.

This work was conducted with the following objects: (*a*) to determine the reaction of the soil before and after the application of different amounts of lime, (*b*) to find the effects of different amounts of lime upon the yield of cane and sugar, as well as upon the quality ratio, and (*c*) to determine the gain or loss resulting from the application of lime.

This experiment was conducted in the Experiment Station of the College of Agriculture from December, 1935, to March, 1936, a period of about fourteen months.

MATERIALS AND METHODS

The field used had an area of 15,450 square meters. The soil is heavy clay loam. The sugar cane variety N. G. 24-A was used.

The lime used in this study was bought in Parañaque, Rizal. Two and one half tons of lime were used. The cost per ton was ₱15.00 and the cost of transportation per ton from Parañaque, Rizal, to the College was ₱4.00. The lime had 35.03 per cent CaO as available lime, according to analysis in the experiment station laboratory, Department of Agricultural Chemistry.

The pH value of the soil was determined by the quinhydrone-electrode method. Two soil samples were taken from each plot and the pH value was determined by the writer with the help of Dr. Nicolas Galvez, of the Department of Soils, and Mr. Lauro Ynalvez, of the Department of Agricultural Chemistry.

The land was prepared in the usual way. The field was plowed four times and harrowed after each plowing. Native implements were used. By running the plow twice along the field, furrows one meter apart were made just before the application of the lime and the planting of the seed pieces.

The field was divided into four lots, each 111 meters by 35 meters, or 3,885 square meters. Each lot was sub-divided into five plots, 111 meters by 5 meters, or 555 square meters. The plots were laid out alternately so as to minimize as much as possible errors resulting from variability in soil fertility. Two guard rows were laid in between every two plots so as to prevent the percolation of water from one plot to another.

All the seed pieces used were about 25 to 35 centimeters long and each had two to five buds. The points were soaked in running water for about 24 hours before planting.

Lime was applied in four different amounts, as follows: first lot, plot A, 83.25 kgm. of lime, or 1.5 tons per hectare; plot B, 138.75 kgm. of lime, or 2.5 tons per hectare; plot C, 194.25 kgm. of lime, or 3.5 tons per hectare; plot D, 216.425 kgm. of lime, or 4.5 tons per hectare. Plot E, not limed, served as the control. The other lots were treated in the same fashion. The lime was broadcasted in the furrow just before planting.

The distance between the hills was 50 centimeters and between the furrows 100 centimeters. For every plot, 840 seed pieces were used; hence, for four plots or replications for each treatment, a total of 3,360 seed pieces were planted. Since there were four replications and one control in the experiment, the total number of seed pieces planted in this study was 16,800.

Between two plots, or treatments, two guard rows were laid. They were planted with different varieties of sugar cane, namely, P.S.A. 14, C.A.C. 128, C.A.C. 126, and POJ 2878.

The whole culture was given the same care. The canes were cultivated six times with a native plow. The first cultivation was done on May 6, 1935, and was a hilling-up process. On May 17, 1935, the cultures were off-barred. Again on June 4, 1935, the cul-

tures were hilled-up and off-barred on June 27, 1935. The last cultivation on July 17-18, 1935, was hilling up or closing in.

Periodic observations were made from the time of planting up to harvesting. The percentage of germination was determined by going over the rows and counting the number of living hills in the rows of the different plots. At maturity, lodging and the attack of pests and diseases were noted. Juice analysis and the actual yield of cane and sugar were determined.

On January 31, 1936, composite cane samples from the different plots were harvested, weighed, milled, and analyzed separately in the U.P. Sugar Mill with the help of Dr. Getulio Guanzon, of the Department of Agricultural Chemistry. A composite sample of the crusher juice from each plot was analyzed and the degree Brix and per cent polarization were determined. From these and other data, the apparent purity, piculs sugar per ton cane, and piculs sugar per hectare of each plot were determined by the use of the *Methods of Chemical Control for Cane Sugar Factories*, published in 1931 by the Association of Hawaiian Sugar Technologists.

Only the millable stalks were harvested and milled. By millable cane stalk is meant a stalk that measures one meter or more from the ground to the last visible node. A stalk less than one meter from the ground to the last visible node was considered non-millable.

In computing the gain or loss resulting from the application of lime, only the cost of the lime, its cost of transportation from Parañaque, Rizal, to College, and the cost of application and of harvesting were considered. The yield of each treated plot was compared with that of the control. The price of a picul of sugar was assumed to be ₱7.80. The value of the difference in yields minus the total cost of lime, cost of its transportation, cost of application, and cost of harvesting gave the gain or loss resulting from the application of lime.

RESULTS AND DISCUSSION

Comparative vigor of plants. As observed prior to harvesting, the plants of the different treatments were vigorous. It was noted, however, that the plants in plots treated with lime were more vigorous than those of the control plots. The plants in plots that received 2.5 tons of lime per hectare were the most vigorous and those in plots treated with 1.5 tons of lime per hectare had practically the same vigor as those of the control.

Comparative maturity of plants. The plants under the different treatments matured at practically the same time as revealed

by the maturity test conducted. Evidently, the maturity of N. G. 24-A was not influenced at all by the application of lime.

Pests and diseases. No major sugar cane disease was observed in any of the cultures. But leaf spot disease caused by *Cercospora kopkei* Kr. was noted in plants of all the different treatments. Pink mealy bug (*Trionymus sacchari* Cockerell) was found in some plants of the different treatments.

Soil reaction. Table 1 shows the pH value of the soil before and after the application of lime. The soil in the field was acidic in reaction before the application of lime, with an average range of 6.56 to 6.59 pH. Examination about thirteen months after the application of lime showed that the soil became basic and the pH value ranged from 7.16 to 7.62. For every increase in the amount of lime applied, there was a corresponding increase in the pH value of the soil. The pH value of the control plots was likewise increased from 6.59 to 7.16 and may be explained as follows: The plots were placed side by side with two guard rows in between. Evidently there was leaching of lime in solution from the treated plots to the control plots during heavy rains, in spite of the presence of guard rows. Arancillo (1934) also found that there was an increase in the pH value of the control plot, owing probably to the fact that the rain water washed off some of the lime of the treated plots on to the control.

Germination of seed pieces. Table 2 shows the percentage of germination of the seed pieces under different lime treatments which ranged from 62.50 to 75.59. The seed pieces from the plots that received 2.5 tons of lime per hectare had the highest percentage of germination with an average of 75.59 per cent. Those from the plots treated with 1.5 tons of lime per hectare had the lowest percentage of germination, with an average of 62.50 per cent, or 3.57 per cent lower than the control, which had an average of 66.07 per cent. The difference may be due to the fact that in the treated lot the seed pieces were too few to allow for an adequate selection of points. But, as a whole, the result shows that lime improved germination, in part resulting probably from its toxic effect upon termites and on the pineapple disease, both found attacking sugar cane points. Calma (1933) and Calma and Valera (1935) found that the pineapple disease was one of the factors responsible for low germination of seed pieces of sugar cane. The beneficial effects of lime on germination may be accounted for in part also by the ability

of the lime to absorb moisture from the air and thus supply sufficient moisture for the germination of the dormant eye buds.

Yields of cane, sugar, and sugar per ton cane. The yields of cane and sugar, and sugar per ton cane resulting from the different treatments are shown in table 3. It will be seen in this table that the average yield of cane ranged from 20.92 ± 4.44 to 28.54 ± 5.20 tons per hectare. The plots treated with 2.5 tons lime per hectare gave the highest yield; those with 1.5 tons, the lowest. The differences of the average yields of cane of the different treatments were insignificant.

By referring again to table 3, it may be seen that the sam . results as with the yields of cane were obtained when the yields of sugar resulting from the different treatments were compared. It will thus be seen that the plots receiving 1.5 tons lime per hectare gave the lowest yield, 39.35 ± 7.12 piculs sugar per hectare, and those receiving 2.5 tons, the highest, 56.42 ± 9.78 piculs sugar per hectare. When the yields of sugar, however, of the different treatments were compared, the differences were insignificant.

In table 3 it will be seen that the average yield of sugar per ton cane ranged from 1.92 ± 0.04 to 2.04 ± 0.02 piculs. The plots treated with 1.5 tons lime per hectare gave the lowest yield of sugar per ton cane, and those treated with 4.5 tons lime gave the highest. The differences, however, between the different treatments were insignificant.

On the whole, these results indicate that lime had a beneficial effect upon the yields of cane and sugar of the cane crop.

That the plots treated with 1.5 tons lime per hectare gave lower yields than the control may be explained by the fact that this treatment gave the lowest percentage of germination, with only 62.5 per cent, which was 3.57 per cent lower than the control.

As a whole, these results agree with the findings of Arancillo (1934), who reported that the application of 2.5 tons lime per hectare approached the optimum, but that for every increase over 2.5 tons in the amount of lime added, there was a corresponding increase in the yields of cane and sugar per hectare. He used 5 and 10 tons lime per hectare as his higher rates of application. Furthermore, the lime that he used had 45.86 per cent calcium (CaO) as available lime, which was 10.83 per cent more than that used in the present work. In the present study, however, the maximum amount of lime added was 4.5 tons only.

Gain or loss resulting from lime application. Table 4 shows the gain or loss resulting from the application of lime. It may be noted in this table that the plots treated with 2.5 tons of lime per hectare gave a computed gain of ₱32.38 per hectare and the plots receiving 3.5 tons of lime per hectare gave a computed gain of ₱4.60 per hectare. Losses of ₱73.88 and ₱21.13 were obtained from the plots treated with 1.5 tons and 4.5 tons of lime per hectare, respectively.

SUMMARY AND CONCLUSIONS

1. Before the application of lime, the soil was acidic in reaction with an average pH value ranging from 6.56 to 6.59. About 13 months after the application of lime, the soil became basic, the pH value ranging from 7.16 to 7.62. For every increase over 1.5 tons of lime per hectare added there was a corresponding increase in pH value of the soil. The pH value of the control plots was likewise increased from 6.59 to 7.16. This increase may be due to the leaching of lime in solution from the treated plots on to the control plots during heavy rains.

2. The plots treated with 2.5 tons of lime per hectare produced the most vigorous plants and those in plots receiving 1.5 tons of lime per hectare had practically the same vigor as those of the control. The maturity of the canes was not influenced by the application of lime. The effects of pests and minor diseases were negligible.

3. The seed pieces from the plots treated with 2.5 tons of lime per hectare had the highest percentage of germination with an average of 75.59 per cent. The seed pieces from the plots receiving 1.5 tons of lime per hectare had the lowest percentage of germination with an average of 62.50 per cent, 3.57 per cent lower than the control which had an average of 66.07 per cent. But, as a whole, the result showed that lime improved germination, probably owing to its toxic effect upon termites and upon the pineapple disease, both of which are commonly found attacking sugar-cane seed pieces. The beneficial effect of lime on germination may be accounted for in part also by its ability to absorb sufficient moisture from the air for the germination of the dormant eye buds. The percentage of germination decreased as the amount of lime added increased. This effect may be accounted for in part by the toxic effect of an excess of lime upon the dormant eye bud.

4. The average yield of cane ranged from 20.92 $\pm$ 4.44 to 28.54 $\pm$ 5.20 tons per hectare. The plots treated with 2.5 tons of lime per hectare gave the highest yield. The lowest yield was obtained

from the plots receiving 1.5 tons of lime per hectare. When the yields of cane per hectare between the different treatments were compared, the differences were insignificant.

5. The plots treated with 2.5 tons of lime per hectare gave the highest yield of sugar per hectare, 56.42 ± 9.78 piculs, and those treated with 1.5 tons of lime per hectare gave the lowest yield, 39.35 ± 7.12 piculs. When the yields of sugar of the different treatments were compared, the differences were insignificant.

On the whole, these results indicate that lime had a beneficial effect upon the yields of cane and sugar of the cane crop. It seems that the application of 2.5, 3.5, and 4.5 tons lime per hectare was near the optimum, as the yields of cane and sugar resulting from these treatments were practically the same, but they exceeded the yields of either the control plots or those treated with 1.5 tons lime per hectare. The plots receiving 1.5 tons lime per hectare and the control gave practically the same yields of cane and sugar per hectare. Undoubtedly, the seepage of lime in solution from the treated plots to the control increased the yields of the latter and thus made the differences insignificant.

6. The average yield of sugar per ton cane ranged from 1.92 ± 0.04 to 2.04 ± 0.02 piculs. The plots treated with 1.5 tons lime per hectare gave the lowest yield of sugar per ton cane, and those receiving 4.5 tons lime gave the highest.

7. The plots treated with 2.5 tons of lime per hectare gave a computed gain of ₱32.38 per hectare and those with 3.5 tons of lime per hectare gave a computed gain of ₱4.60 per hectare. A loss of ₱73.88 was obtained from the plots treated with 1.5 tons of lime per hectare, and ₱21.13, from those receiving 4.5 tons per hectare.

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TABLE 1

Soil reaction resulting from the application of lime [a]

AMOUNT OF LIME PER HECTARE	NUMBER OF REPLICATIONS	AVERAGE pH [b]	
		Before liming	After liming [c]
tons			
1.5	4	6.56	7.29
2.5	4	6.59	7.43
3.5	4	6.56	7.51
4.5	4	6.59	7.62
Control	4	6.59	7.16

[a] pH value was determined by quinhydrone electrode.
[b] Four determinations; two samples from each plot.
[c] pH value after liming was determined when canes were thirteen months old.

TABLE 2

Percentage of germination under the different lime treatments

AMOUNT OF LIME PER HECTARE	NUMBER OF PLANTED HILLS	NUMBER OF HILLS WITH PLANTS	PERCENTAGE OF GERMINATION
tons			
1.5	3360	2100	62.50
2.5	3360	2540	75.59
3.5	3360	2460	73.21
4.5	3360	2420	72.03
Control	3360	2220	66.07

TABLE 3

Comparative average computed yields of cane and sugar per hectare and piculs sugar per ton cane resulting from the different treatments

AMOUNT OF LIME PER HECTARE	AVERAGE YIELD OF CANE PER HECTARE	AVERAGE YIELD OF SUGAR PER HECTARE	AVERAGE YIELD OF SUGAR PER TON CANE
tons	*tons*	*piculs*	*piculs*
1.5	20.92 ± 4.44	39.35 ± 7.12	1.92 ± 0.04
Control	22.91 ± 2.43	44.37 ± 4.65	1.94 ± 0.02
Difference	−1.99 ± 5.10	−5.02 ± 8.51	−0.02 ± 0.05
	Insignificant	Insignificant	Insignificant
2.5	28.54 ± 5.20	56.42 ± 9.78	1.98 ± 0.02
Control	22.91 ± 2.43	44.37 ± 4.65	1.94 ± 0.02
Difference	5.63 ± 5.74	12.05 ± 10.83	0.04 ± 0.03
	Insignificant	Insignificant	Insignificant
3.5	27.50 ± 3.02	55.34 ± 6.17	2.01 ± 0.02
Control	22 91 ± 2.43	44.37 ± 4.65	1.94 ± 0.02
Difference	4.59 ± 3.88	10.97 ± 7.73	0.07 ± 0.03
	Insignificant	Insignificant	Insignificant
4 5	27.23 ± 2.75	55.66 ± 5.77	2.04 ± 0.02
Control	22 91 ± 2.43	44.37 ± 4.65	1.94 ± 0.02
Difference	4.32 ± 3.67	11.29 ± 7.42	1.10 ± 0.03
	Insignificant	Insignificant	Slightly significant
1.5	20.92 ± 4.44	39.35 ± 7.12	1.92 ± 0.04
2.5	28.54 ± 5.20	56.42 ± 9.78	1.98 ± 0.02
Difference	7.62 ± 6.86	17.07 ± 12.10	0.06 ± 0.05
	Insignificant	Insignificant	Insignificant
1.5	20.92 ± 4.44	39.35 ± 7.12	1.92 ± 0.04
4.5	27.23 ± 2.75	55.66 ± 5.77	2.04 ± 0 02
Difference	6.31 ± 5.26	16.31 ± 9 17	0.12 ± 0 05
	Insignificant	Insignificant	Insignificant
2.5	28.54 ± 5.20	56.42 ± 9 78	1.98 ± 0.02
3.5	27.50 ± 3.02	55.34 ± 6.17	2.01 ± 0.02
Difference	1.04 ± 6.01	1.08 ± 12.03	0.03 ± 0.03
	Insignificant	Insignificant	Insignificant
2.5	28.54 ± 5.20	56.42 ± 9 78	1 98 ± 0.02
4.5	27.22 ± 2.75	55.66 ± 5 77	2.04 ± 0.02
Difference	1.32 ± 5.88	0.76 ± 11.52	0 06 ± 0.04
	Insignificant	Insignificant	Insignificant
3.5	27.50 ± 3.02	55.34 ± 6.17	2 01 ± 0 02
4.5	27 22 ± 2.75	55.66 ± 5.77	2.04 ± 0.02
Difference	0.28 ± 4.08	0.32 ± 8.45	0.03 ± 0.02
	Insignificant	Insignificant	Insignificant

TABLE 4

Gain or loss under the different application of lime

AMOUNT OF LIME PER HECTARE	AVERAGE YIELD PER HECTARE	TOTAL COST OF LIME APPLICATION AND COST OF HARVESTING THE INCREASE IN YIELD PER HECTARE [a]	INCREASE OR DECREASE IN YIELD	VALUE OF INCREASE PER HECTARE [b]	GAIN OR LOSS DUE TO LIME [c]
tons	*piculs*	*pesos*	*piculs*	*pesos*	*pesos*
1.5	39.35	34.73	— 5.02	—39.15	—73.88
2.5	56.42	61.61	+12.05	+93.99	+32.38
3.5	55.34	80.96	+10.97	+85.56	+ 4.60
4.5	55.66	101.38	+10.29	+80.25	—21.13
Control	44.37				

[a] Cost of lime per ton was ₱15.00.
Cost of transportation of lime from Parañaque, Rizal, to College was ₱4.00 per ton.
Cost of labor per hour was assumed to be ₱0.10.
Cost of harvesting per ton cane was assumed to be ₱1.61.
[b] Current price of sugar per picul was assumed to be ₱7.80.
[c] "+" equals gain and "—" equals loss.

COTTON GROWING IN TEXAS [1]

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WITH FOUR TEXT FIGURES

The leading cotton-producing states in the United States are Texas, Georgia, North Carolina, South Carolina, Alabama, Mississippi, Arkansas, Oklahoma, Virginia, Tennessee, Arizona, Louisiana, and California. The state of Texas alone produces nearly two-fifths of the whole crop of the Union and about one-sixth of the output of the world. According to the Texas Almanac (1926), the total annual value of the lint crop of Texas was at that time approximately equal to the whole raw production of gold, silver, zinc, lead, and copper in the United States. More than three million Texans and many more millions in the spinning and manufacturing centers of the United States, especially in the New England States, in Pennsylvania, Indiana, and New York, and in the Carolinas, in England, Germany, France, Belgium, and Japan obtain their livelihood from Texas cottons.

The area devoted to cotton growing in the state of Texas is rapidly increasing. This is primarily due to the invention of the harvester, to the intensive methods of cultivation in the old cotton districts, and to the rapid development of cotton growing in many parts of Texas, such as in the south plains, in the south, and in the southeast. With the exception of the southeastern and southwestern parts of Texas, the whole state is a heavy producer of cotton.

The state of Texas has an area of 265,896 square miles, or 167,934,720 acres. In 1928, 17,766,000 acres were devoted to cotton growing. This area produced 5,150,000 bales of cotton and gave an income of $450,625,000. The state of Texas has four strong rivals in cotton production. They are India, China, Egypt, and Brazil. With the exception of India, Texas outranks all other countries in cotton production, the former devoting about 21,000,000 acres to its cultivation and the latter, about 17,000,000 acres. Texas has the

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[1] The data presented in the present paper were collected in 1931–1933 when the writer was pursuing graduate work in the University of Texas. The manuscript was revised and improved in June, 1937, by Dr. Glenn W. Goldsmith, professor of botany in the University of Texas.

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advantage over its rivals in that it uses modern methods of growing the crop. To-day, Texas is known for its cattle in the world meat production, for its great petroleum output, and for cotton in the textile market.

Leading cotton counties of Texas. Although the soil resources of the state of Texas are great and its land areas vast, not all counties produce much cotton. The yield per acre has been declining steadily on account of the rapid spread of the boll weevil, the use of too many varieties, and the careless methods of cultivation pursued.

Not less than 168 of the counties of Texas produce some amount of cotton. Among some of the leading counties which produce considerable quantities are Collin, Navarro, Lamar, Ellis, Kaufman, Williamson, Hunt, Dallas, Hill, McLennan, Jones, Johnson, Millam, Grayson, Bell, Fannin, and Taylor.

Climate. Texas has a warm climate in summer. In winter the temperature seldom falls below zero on the coast, while in the extreme north, it may fall several degrees below the freezing point. In the western uplands the temperature rises above 100°F. and on the coast it rises to about 95°F. The whole state is affected by cold winds known as northers, especially in winter. The winds from the Gulf of Mexico bring abundant rains to the southeastern part of Texas. The annual amount of precipitation varies in different sections of the state, being heaviest along the southern and southeastern regions and driest in the regions near El Paso. Abilene, located almost at the center of the state, has an average annual precipitation of about 25 inches. The city of Austin, capital of Texas, has an annual precipitation of about 34 inches.

Soil. The Texas soils are of widely different characteristics and features. The alluvial soils are found along the lower river courses. The black prairie soils are fertile, being a mixture of clay and limestone. The coastal plains are generally sandy in character. In some parts of Texas, especially along the coastal plains, the soil is black in appearance, owing to the presence of black minerals and of loam in it. In the northern part, especially in the northwestern region, the soil is red. This red color of the soil is largely due to the presence of iron. The soils of the state include all classes, from sand to silt, though fine sandy loams, clay loams, clay and silty loams predominate.

Cotton is grown on practically every type of soil and in nearly all farming regions of Texas. At the present time effort is being made by the Federal Government to grow but one variety in each

community. Most of the crop is grown on the black land prairie soils and on the black sandy loam soils.

Varieties. The total number of cotton varieties grown in Texas probably run to several hundred. Among some of the leading cotton varieties are the Acala, best adapted to the southwestern conditions, the Pima Egyptian, the Half and Half, the Texas Big Boll varieties, as the Mebane and Lone Star, the Triumph, the Startex, the Truitt, the Belton, the New Boykin, the Kasch, the Harper, and many others. The Acala variety has been found in many formal tests to be more productive than many of the Texas Big Boll varieties. Its lint is superior to that of the ordinary short-stapled cotton varieties. The Half and Half variety is one of the heaviest, if not the heaviest, cotton yielding varieties in Texas. The main trouble with it is that the staple is short, and because of this, the farmers are beginning to plant other varieties instead.

The varieties named above are grown commonly in almost all cotton sections west of Texas.

Seed selection. The Texas cotton farmers seldom select their seed for planting purposes, as seeds are easily secured from the various experiment stations in the cotton-growing districts of the United States, from gins, and from cotton seed farms numbering about 50 in the state. Among some of the cotton seed farms from which the Texas cotton farmers obtain their seeds are:

1. Ferguson Seed Farms, Howe, Texas. This seed farm company is famous for its New Boykin and Ferguson Triumph 460 varieties.
2. Delta & Pine Land Co., Scott, Mississippi, famous for its D. P. L. 10 variety.
3. J. W. Davidson & Co., McKinney, Texas, known for its Sunshine variety.
4. Ferris Watson, Garland, Texas, noted for its Watson variety.
5. Agricultural Experiment Station, Stillwater, known for its Oklahoma Triumph 44.
6. Stoneville Pedigreed Seed Co., Stoneville, Mississippi, famous for its Stoneville variety.
7. John D. Rogers, Navasota, Texas, noted for its Acala variety.

Preparation of the land. In the southern part of Texas, the land is prepared about the end of winter or early part of spring, usually as early as January and as late as March. In the northern part of the state, the land is prepared in February or March. The time

varies considerably with the locality and the season, as some winters are much more favorable for work than others.

After all frost has disappeared, the soil is plowed once or twice with a lister. Lister plows are of different types and models. Heavy lister plows are pulled by at least two mules, usually four, and are commonly used in breaking heavy types of soils. The use of the gasoline tractor is rapidly coming into favor especially in the central and western portion of the state where fields are large and level. A light lister pulled by one mule is usually used in plowing sandy or sandy loam soil.

There are two general methods used in plowing the land: The first one is by bedding or listing and the second is by broken broadcast. The first method consists in running the lister in the ridge of the old row, forming a new bed, or by turning a plow of two-or three-mule size so as to form a furrow right through the old middle, thereby throwing one or two furrow slices toward it from each side. The second method consists in breaking the whole field with the small disc harrows or with cultivators provided with discs or shovels for making a ridge.

Breaking the land for cotton planting varies from 3 to about 8 inches deep, although most of the cotton lands are broken from 3 to 4 inches. The deeper cultivations, subsoiling, are commonly done by means of tractor and in the heavier soils have proved beneficial.

To reduce erosion, terracing the fields has of late become common although not extensive. The loss of soil from erosion owing to the heavy rains is thereby greatly reduced in rolling country. Light soils, as sand and sandy loam, are plowed deeper than heavy soils, such as clay and clay loam, since the plow runs more easily through the sandy type. In regard to the methods and implements used in the preparation of land for cotton planting, the reader is referred to figure 1 of this paper.

Time and methods of planting. The time of planting cotton varies in different places of Texas on account of climatic differences. In the southern part, sowing the seeds begins as early as the latter part of February and as late as the first week of March, while in the northern part, it commences in the latter part of April and lasts around the first week of June. The average time of planting for the whole state is around the middle part of April.

There are two general methods of planting the cotton seed, by hand and by drill. The drill method is illustrated in figure 2. Most

of the cotton farmers use the single-row drill planter pulled by a mule; this planter opens a small narrow furrow, drops the seeds, and then covers them. Some of the planters drop about ten seeds in a hill and space the hills according to the desired distancing. Few farmers use the double-row drill planter. It is used only in drilling the cotton seeds on lands which are level and where the broken broadcast method of plowing the field has been used.

Where the single-row drill planter is used, about eight gallons of seeds are planted on an acre of land (0.4047 ha.) Where the planting is by hand, a less quantity of seed is needed, only about four gallons.

Fig. 1.—Bursting out middles, or ridges, and uprooting stalk stubble. Preparing land for cotton planting

Distance of planting. The distance between the rows varies from 3 to 4 feet. Most of the cotton farmers of Texas plant their seeds 3½ feet between the rows.

The distance between the plants in the rows varies from 6 to 18 inches. Most of the farmers space their hills 12 inches apart.

Thinning. As soon as the seedlings have attained a height of from 4 to 6 inches above the ground, Negro laborers thin them to one or two plants to a hill. Some Mexicans are employed in thinning the seedlings in the southern part of Texas. As the Negroes or Mex-

icans move along in the thinning work, they gossip, joke, or sing. In certain sections of the state, white tenants thin the cotton seedlings.

Weeds. Johnson grass (*Sorghum halepense*), although a valuable forage crop in the western part of Texas, is one of the worst weeds in the cotton fields of the southern and western parts. If allowed to become established in a field, it must be removed largely by hand. Bindweed (*Convolvulus repens*) is widely distributed in the cotton fields and is chiefly injurious because of its deep root which, not only lies below the usual plow depth, but also harbors the cotton root-rot fungus. Bagweed (*Ambrosia trifida*), cocklebur (*Xanthium spinosum*), and sunflower (*Heliantus annuus*) are common throughout the state. In the northern portion of the cotton

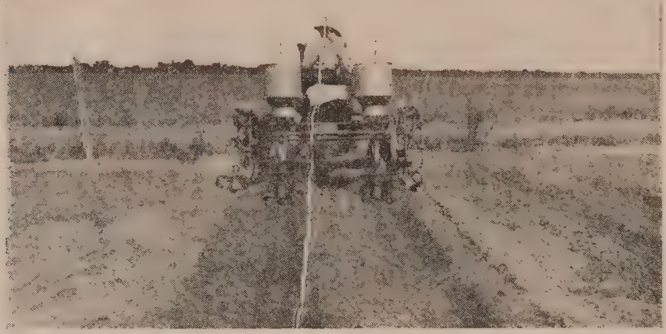

Fig. 2.—Planting in the lister furrow with two-row tractor planter

section the Russian thistle (*Salsola kali*) assumes a prominent place as a weed of the cotton fields.

Cultivation. The first plowing of the rows of cotton begins when the plants are well above the ground. This is done in order to destroy the weeds and at the same time pulverize or loosen the surface of the soil. A scrape or turning plow is commonly used to kill the weeds, especially if the cotton fields have become very weedy. For the first plowing of the field, a cultivator known as "Monitor" or "Godevil" is commonly used by many of the planters.

For the second plowing or cultivation, a cultivator provided with from three to five small shovels or cutters is in common use. For subsequent or later cultivations, sweeps are used. The sweeps are buzzard-wing in shape, provided with two sharp cutting blades.

After sweeping down the weeds and the soil, the cotton field is left uncultivated until the cotton plants mature. See figure 3.

Blooming season. When the cotton plants are about 45 days old, they begin to produce squares. These squares develop into flowers in from two to three weeks after their first appearance. In most parts of Texas, the average date of bloom is either in the latter part of May or early part of June. Two days after the flowers open, the petals begin to wither away. At this time, the future bolls appear like a small knob, usually of the size of a mungo seed. These bolls burst open in from 1½ to 2 months after their first appearance.

Insect pests. The most destructive insect that has ever attacked the cotton plant is the Mexican boll weevil (*Anthonomus grandis*

Fig. 3.—One-row walking cultivator

Boh.). Both the adult and the larva damage the squares, flowers, and bolls of the cotton plant. The adult weevil feeds on the young buds of the plant and then attacks the squares and bolls by puncturing them. The larva feeds on the squares and young bolls. The Mexican boll weevil is partly controlled by the hot, dry, summer conditions; by the extreme cold, winter weather; and by the use of calcium arsenate spray. During recent years the damage from the boll weevil has diminished considerably, owing to natural but undetermined causes.

The pink boll worm (*Pectinophora gossypiella* Saunders) is one of the most destructive cotton insects, probably ranking second in this respect. The larva of the moth enters the seed and eats the

kernel. The lint of the infested bolls fails to develop normally and becomes short and curly. The injury is minimized by fumigating the seed and sterilizing it with heat, by collecting all infested plants and trash and burning them, by the use of traps as lights, and by the use of irrigation.

The cotton bollworm (*Chloridea obsoleta* Hübn.) is also known as corn earworm, tomato fruitworm, and tobacco budworm. The eggs are laid on the leaves of the cotton, tomato, and tobacco plants, and after they are hatched, the larvae or caterpillars fed on the surface of the leaves and then attack the squares and bolls of the cotton plants or the tassels and kernels of the corn plants. The cotton planters of Texas minimize the injury by plowing the ground at the proper time, late fall or early winter; by poisoning the insect while the caterpillars are feeding on the surface of the leaves; by hastening the maturity of all crops affected; by the use of corn or tobacco as trap to protect the cotton plants; and by modifying farm practices.

The cotton army worm (*Alabama argillacea* Hübn.) is one of the most destructive cotton pests. It is sometimes known as cotton leaf worm because the caterpillars devour the leaves, and at times some planters call it cotton caterpillar because it is the caterpillar that does the real damage by eating the leaves. The cotton army worm eats the leaves, flowers, bolls and soft, tender, immature parts of the cotton plant. It serves as a distinct help to the cotton pickers if the caterpillars attack the leaves just before picking time, for picking or snapping the staple from the lock is facilitated. At times the caterpillars rob the Mexican boll weevil of food during the latter part of the season, for they are voracious eaters, practically leaving no leaf on the cotton plant. The cotton army worm is readily controlled by the use of calcium arsenate or lead arsenate spray, applied in the morning when the leaves are still moist.

The cotton mite (*Tetranychus telarius* L.) is usually known as cotton red spider. It appears on the under surface of the leaf of the cotton plant and sucks the juice of the leaf, making it curly and red in color. The injury is minimized by collecting and burning all affected plants and by spraying the affected plants with kerosene soap emulsion or lime sulfur emulsion.

The cotton stainer (*Dysdercus suturellus* H. Schf.) is a red bug which sucks the juice of the squares and bolls with its long beak or proboscis. The punctured seed of the boll exudes a kind of juice which stains the lint yellow. The control measure used is burning

the old cotton stalks and trash and collecting the nymphs or bugs in a can with kerosene in it.

The cotton flea hopper (*Psallus seriatus* Reuter) is a small green bug. The adult hoppers are about the size of the flea, and brown in color. The nymphs are slightly smaller. The young cotton squares are blasted by the hoppers. Control measures consist of dusting the plants with nicotine sulfate, calcium arsenate, sulfur flower, and other insecticides.

The cotton leaf perforator (*Bucculatrix thurberiella* Busck) does considerable damage to the cotton plant in Texas, especially when the larvae become abundant. The insect is a tiny moth, gray in color, and 3 to 4 millimeters long, 0.8 millimeters wide. The larvae are threadlike; they feed on the leaves of the cotton plant, causing holes in them. The control measures are collecting and burning all of the infested plants and spraying the plants with arsenical poison.

The cotton aphis is a small green louse (*Aphis gossypii* Glover) usually found on the under surface of the cotton leaves. It sucks the juice of the cotton leaf, making it curly and dwarfed. It is controlled by contact sprays, such as nicotine sulfate or Black Leaf 40 spray.

Among some of the grasshoppers which are rather destructive to the cotton plants are the meadow grasshoppers, the shield-backed grasshoppers, and the short-horned grasshoppers of various kinds. Some of the plant bugs injurious to the cotton bolls are the pentatomids, the coreids, and the pyrrhocorids. They are partly controlled by handpicking and by killing all the mesquites, tomatoes, okras, and dahlias that grow near the cotton plants.

Diseases. The most destructive disease that has ever attacked the cotton plant in Texas is known as the Texas root rot [*Phymatotrichum omnivorum* (Shear) Duggar]. The attacked plants begin to wilt, the leaves become dry and black, and finally the plants die. The attacked plants appear in irregular patches and at times cover large areas or the whole fields. The attacked cotton fields look as though the plants had been burned. The roots of infected cotton plants show white mycelia when newly attacked, turning into brown threads as they become older. No effective control measure has yet been discovered, although deep fall plowing, long, continuous crop rotation, and the use of immune crops have given some beneficial results.

The anthracnose of cotton (*Glomerella gossypii* South) is also a disease of the cotton plant in Texas. It attacks practically all parts of the cotton plant, as the leaves, stem, and bolls. The infected parts appear red at first, then they turn black and finally pink as soon as the spores are produced. The spores and filaments of the causal organism are carried with the bolls, stalks, leaves, and seeds of the cotton plant, but the most common medium of infection is the seed. Control measures consist of deep fall plowing, the use of resistant varieties, the use of two-year old seed, and crop rotation, all of which have been found to be effective in lessening the injury caused by this disease.

The wilt disease (*Fusarium vasinfectum* Atk.) of cotton is characterized by the dwarfed appearance of the plants and by the dried margins of the leaves. The inside parts of the woody portion of the stem of the plant is either brown or darkened in appearance. The injury is partly controlled by the use of resistant varieties, burning the diseased plants, and crop rotation.

The root gall, or knot of cotton (*Heterodera radicicola* Greef) is characterized by the presence of irregular knots or galls in the roots. The very minute worms enter the roots of the cotton plant, causing galls in them. The infected plants appear stunted, pale and yellowish in color. The application of various chemicals, as sulfur, formaldehyde, ammonium sulfate, and fertilizers, and the use of crop rotation and cyanamid spray have been found to reduce the injury caused by root galls.

The rust of cotton is usually common on the poor soils of the cotton sections of Texas. The application of fertilizers containing a good amount of potash has been found to lessen the injury caused by rust of cotton.

Among some of the cotton diseases of lesser importance usually found common in the cotton regions of Texas are the boll rots, damping-off, blights of various kinds, mildews, and wilts. Although the losses due to various plant and animal parasites vary greatly from year to year, the average is probably not far from 25 per cent of the cotton crop.

Harvesting. In southern Texas picking begins in the later part of July or early part of August and in the northern part, in late August or early September. Picking continues up to November or December or even to January. Negroes and Mexicans are usually employed as pickers. During the harvest season the Mexicans flock to the cotton regions of Texas. They are paid from 50 to 75 cents

for 100 pounds of seed cotton. In places near the cities and mills, they are paid as high as 75 cents to $1.00 per hundred pounds of seed cotton, the average rate being around 75 cents. An experienced and skillful picker earns from $3.00 to $5.00 a day.

Each picker carries a long sack, held in place by a leather or cotton strap over his shoulder. As he goes forward, he drags the long sack over the ground. The Negroes and Mexicans usually work in groups of four or five. As they move from plant to plant, they talk, joke, gossip, sing, and whisper. In certain sections of the cotton regions of Texas, native farmers are employed in picking cotton. They work more constantly and seriously than the Mexicans or Ne-

Fig. 4.—Cotton stripper and bur extractor-cleaner developed by the division of agricultural engineering of the Texas Agricultural Experiment Station, as it was used in October and November, 1936

groes, as they are more interested in completing their work as soon as possible.

Recently a number of mechanical pickers have been devised and are now in the market for sale. These pickers have been tried by different cotton planters and have been acclaimed to do faster work than ordinary hand picking. See figure 4.

Yield. The yield per acre in the different cotton regions of Texas varies a great deal. On poor, very light soils, the yield per acre is as low as one-fifth of a bale (around 100 pounds of clean

cotton); on poor heavy soils, around one-fourth of a bale; on ordinary soils, around one-half or one bale; on rich sandy loam or alluvial soils, as high as from one to one and a half bales. The average yield of clean cotton for the whole state is considerably less than half a bale, or for the period 1920 to 1930, about 130 pounds per acre.

Ginning. There are two types of machines in use in the cotton sections of Texas, the roller gin and the saw gin. The roller gin is seldom used, as most of the planters grow the American Upland short-staple cottons.

Gins may be private or public and are provided with pneumatic elevators which suck the seed cotton from the wagon which hauls it. The elevators are telescopic in construction, and are made of metallic tubes, about 12 inches in diameter equipped with revolving fans. The elevators carry the seed cotton into the cleaner and separator, where it is forcibly thrown against a wire screen so as to remove the dirt. From the cleaner the seed cotton is conveyed to the distributor which is provided with a large belt that travels over the top of the gin stands. This belt is provided with fingers which assist in delivering the seed cotton into the feeders. The feeders are rollers provided with spikes which pick up the seed cotton and drop it to the revolving saws in the roll box, usually known as breast gin, or gin breast. The gin saws are made of steel discs, from 10 to 12 inches in diameter. A single gin contains from 40 to 80 revolving saws, usually 70 and 80. Each gin is capable of turning out from 8 to 15 bales of clean cotton a day, depending upon the amount of cotton supplied, the number of revolving saws, the moisture content of seed cotton that is being ginned, length of the staple, and the number of revolutions in which the saws are turned per minute. Each revolving saw pulls the lint through the slit between the gin ribs. Behind the saws is a revolving cylinder provided with fine wire bristles which serve to remove the lint from the saws. The lint removed from the saws is carried by means of air currents to the condenser, a screen roller over which the lint is blown. The lint collected on this roller forms a fairly compact layer of cotton which is now ready for pressing or baling.

Baling. The lint cotton which has accumulated in the condenser is conveyed into the press box. On the bottom of the press box is placed the tare, usually of burlap material or jute. As the lint drops in the press box, it is pressed by a mechanical tramper, and when enough cotton to make a 500-pound bale has accumulated in the box, bagging of jute or other material is placed on it and heavy pressure

applied. After pressing the cotton into the desired density and size, six iron straps are placed around each bale and fastened. The pressure applied is now released, and the cotton bale expands to the standard size, usually 27 inches thick, 45 inches wide, and 54 inches long.

Classifying. Cottons in Texas are either baled round or flat, but the latter is the more common form. Where the bales are round, lint samples are taken while each bale is in the press; where the bales are flat, lint samples are taken by making cuts on the bales and withdrawing the sample from each by the fingers or hooks. Each bale of cotton is classified by licensed classifiers. These licensed classifiers classify the cotton bales according to grade only, to staple only, to any single quality, as color, fineness, length of staple, amount of moisture, etc., and to two or more of the qualities enumerated above.

Marketing. The system of cotton marketing is very complex. Most of the small cotton planters sell their cotton to local buyers. Some of them sell their cotton in other places. The cotton bought by the local buyers is sent to larger markets for proper classification, or it may be sent directly to the large cities, which have a number of cotton mills, for manufacture. Again these larger markets, usually known as the interior markets, send the cotton to the leading export markets of the United States, as New York, Galveston, New Orleans, and Savannah. These export markets send the cotton to other foreign markets, as Liverpool, Manchester, Genoa, Barcelona, Bremen, Osaka, Tokyo, etc.

ACKNOWLEDGMENT

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A STUDY OF FRESH COCONUT MEAT AS A FEED FOR GROWING AND FATTENING PIGS [1]

ANSELMO P. AFALLA

So far as the writer knows, no study has been made of coconut as a hog feed. It may be of interest, however, to consider one experiment on the feeding of coconut oil, inasmuch as this constitutes an important component of fresh coconut meat. Langworthy and Holmes (1917)[2], experimenting on the feeding value of coconut oil, olive oil, cotton seed oil, peanut oil, sesame oil, and cocoa butter, each combined with a single mixed diet, to normal young men of good health and in moderate active condition, reported that, with allowance for metabolic products, the coefficients of digestibility was found to be 97.9 per cent for coconut oil, 97.8 for cotton seed oil, 97.8 for olive oil, 97.3 for peanut oil, 90.0 for sesame oil, and 94.9 for cocoa butter. These values indicate the high coefficient of digestibility of vegetable oils, particularly coconut oil. The foregoing authors further stated that 131 grams of coconut oil eaten by one of the subjects for a one-day period produced no abnormal alimentary symptoms. The average energy value (heat of combustion) of coconut oil consumed per man daily was 2,305 calories. Judged from the results of this investigation, coconut oil is readily assimilable by the body and is a satisfactory food.

Objects of the present work

The objects of this study were to determine the effects of feeding coconut meat to pigs: (*a*) when one-half of the corn in a standard ration is replaced by double the amount by weight of fresh coconut meat and (*b*) when all the corn is replaced by twice the amount of coconut meat.

Time and place of the work

The work was begun on August 28, 1933, and closed on March 25, 1934, covering a period of 210 days, divided into three seventy-day periods. It was conducted in the Department of Animal Husbandry.

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[1] Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture; Experiment Station contribution No. 1204. Prepared in the Department of Animal Husbandry under the direction of Dr. Mariano Mondoñedo.

[2] LANGWORTHY, C. F., AND A. D. HOLMES. 1917. Digestibility of some vegetable fats. United States Department of Agriculture Bulletin 505: 1-19.

MATERIALS

Animals used. Twenty-four Berkjala weanling pigs about two months old were used at the start of the experiment.

Feeds used. The feeds used were ground corn, rice bran, copra meal, shrimps, and grated fresh coconut meat. The following are the analyses of the different feeds:

	Corn [a]	*Fresh coconut meat* [b]	*Copra meal* [c]
Moisture	13.53	48.37	8.91
Fat or ether extract	1.25	33.29	8.88
Ash	1.57	1.19	5.76
Protein (N × 6.25)	7.47	3.62	14.97
Crude fiber	1.63	2.96	13.33
Carbohydrates (N. F. E.)	74.55	10.57	48.15
Total	100.00	100.00	100.00
Calories per 100 grams	341.38	368.00	347.91
Nutritive ratio based on chemical analyses	1:10.36	1:23.61	1:4.55

To meet the requirements of the pigs as they grew older, the proportion by weight of the feeds used was varied from the first to the third seventy-day periods.

RATIONS FOR THE FIRST SEVENTY-DAY PERIOD

Feeds	*Lot I*	*Lot II*	*Lot III*
Corn	15	7.5	0
Coconut meat	0	7.5(× 2)	15(× 2)
Rice bran	60	60	60
Copra meal	15	15	15
Shrimps	10	10	10

RATIONS FOR THE SECOND SEVENTY-DAY PERIOD

Feeds	*Lot I*	*Lot II*	*Lot III*
Corn	20	10	0
Coconut meat	0	10(× 2)	20(× 2)
Rice bran	60	60	60
Copra meal	15	15	15
Shrimps	5	5	5

RATIONS FOR THE THIRD SEVENTY-DAY PERIOD

Feeds	*Lot I*	*Lot II*	*Lot III*
Corn	25	12.5	0
Coconut meat	0	12.5(× 2)	25(× 2)
Rice bran	60	60	60
Copra meal	13	13	13
Shrimps	2	2	2

[a] Analyzed by the Department of Agricultural Chemistry, College of Agriculture.

[b] ADRIANO, F. T., AND M. MANAHAN. 1931. The nutritive value of green, ripe, and sport coconut (*buko, niog, and macapuno*). The Philippine Agriculturist 20: 195–198.

It may be noted that 2 parts of fresh coconut meat were used to replace 1 part of corn. Having no previous knowledge of the comparative feeding value of the two feeds, but knowing that fresh coconut meat has a higher moisture content than corn, a 2 : 1 ratio was arbitrarily selected for trial. Throughout the discussion, therefore, 2 parts coconut meat should be considered as one unit compared with one unit of corn.

The following, based on chemical analysis, is the ratio of protein to carbohydrates plus fats × 2.25 in the rations used:

Rations of:	*Lot I*	*Lot II*	*Lot III*
First 70-day period	1:5.93	1: 8.08	1: 9.96
Second 70-day period	1:6.44	1: 9.21	1:11.51
Third 70-day period	1:6.86	1:10.19	1:12.86

The average prices of feeds used at the time of the feeding experiment were:

Feeds	*Unit*	*Prices*	*Wt. in kgm.*	*Cost per kgm.*
Corn	100 ears	₱ 0.52	12.00	₱0.043
Coconut, whole nut	100 nuts	0.76	117.17	0.006
Fresh coconut meat	100 nuts	0.76	31.28	0.025
Rice bran	Cavan	0.90	25.00	0.037
Copra meal	Ton	27.00	1000.00	0.027
Shrimps	Cavan	1.80	12.00	0.150

Mineral mixture used

Common salt	45 parts
Ground corncob charcoal	45 "
Slaked lime	10 "
Total	100 parts

Two kilograms of mineral mixture were added to every 100 kilograms of feed mixture used. One kilogram of mineral mixture costs ₱0.031.

Nature of the feed under study. Coconuts grown in Los Baños, Laguna, were used.

The average weight of the nuts was 1,171.7 grams each. The husks constituted 41.80 per cent of the total weight of the nut; shell and water, 31.50 per cent; and coconut meat, 26.70 per cent.

METHODS

Allotment of pigs

The experiment consisted of three lots of six pigs each. In alloting the pigs for the experiment care was taken that the lots were uniform as to sex, weight, and condition. There were three barrows and three gilts in each lot.

Preparation of the coconut meat

In the preparation of the coconut feed, enough coconut meat was grated in the afternoon for feeding in the evening and the following morning. The nuts were grated by hand with a native coconut grater. Just before feeding, the grated coconut meat was added to the other constituents of the ration of the lots receiving this particular feed.

Feeding and management

Feeding was made at 6:00 a. m. and at 6:00 p. m. in the hog barn. The pigs were also given camote soilage at the rate of one per cent of their live weight. They also had access to a second growth camote pasture. For protection during bad weather the animals were kept in the hog house; otherwise, they were turned loose in paddocks and pastures. They were bathed at noon on warm days.

OBSERVATIONS

First seventy-day period

The pigs in lot I (control, corn lot) were healthy and in good condition, with the exception of one which registered a decrease in weight for a time but regained it towards the end of the first period.

Lot II pigs (coconut and corn lot) ranked next to lot III as to feed consumption and rapidity of gain. They were fairly healthy, and appeared similar in condition to those of lot III.

Lot III pigs (coconut lot) consumed their feed with great relish. The pigs were all healthy and in good condition, except one which made rather slow gain in weight. They were more refined than the pigs of the other lots, with glossy hair and smooth skin.

Second seventy-day period

Lot I pigs consumed less feed and made slower gains than those in lots II and III.

Lot II pigs again ranked next to lot III as to feed consumption and gain in weight. They were observed to have as good an appetite as the pigs of lot III. They were larger than the pigs in lot I.

Lot III pigs continued to consume the largest amount of feed of the three lots. All were in good condition and had good appetites. They consumed their ration the fastest of the three lots. They looked contented and quiet.

Third seventy-day period

Lot I pigs were all in good condition. They were, as a whole, smaller in size than pigs in lots II and III. They continued to consume less feed and made less gain than the pigs of lots II and III.

In size, lot II pigs were intermediate between lots I and III. They were in good condition and appeared to be suitable for the market.

Lot III pigs continued to consume a greater amount of feed and to be larger than the pigs of the other lots. They appeared very uniform in size, well fattened, and were the best fitted for market of the three lots.

Summary of results

	LOT I	LOT II	LOT III
First seventy-day period			
Average initial weight in kgm.	7.89	7.83	7.77
Average final weight in kgm.	14.13	17.67	19.03
Average daily gain per pig in kgm.	0.09	0.14	0.16
Feed consumed per kgm. gain in kgm.	4.22	2.72	2.41
Feed cost per kgm. gain in centavos	19.79	12.85	11.48
Second seventy-day period			
Average initial weight in kgm.	14.13	17.67	19.03
Average final weight in kgm.	29.00	33.37	43.17
Average daily gain per pig in kgm.	0.21	0.22	0.35
Feed consumed per kgm. gain in kgm.	4.46	3.94	3.05
Feed cost per kgm. gain in centavos	18.52	16.52	13.29
Third seventy-day period			
Average initial weight in kgm.	29.00	33.37	43.17
Average final weight in kgm.	44.67	54.43	71.83
Average daily gain per pig in kgm.	0.22	0.30	0.41
Feed consumed per kgm. gain in kgm.	5.84	3.98	3.36
Feed cost per kgm. gain in centavos	22.53	15.57	13.40
Combined two hundred ten-day period			
Average initial weight in kgm.	7.89	7.83	7.77
Average final weight in kgm.	44.67	54.43	71.83
Average daily gain per pig in kgm.	0.17	0.23	0.31
Feed consumed per kgm. gain in kgm.	5.01	3.57	3.11
Feed cost per kgm. gain in centavos	21.18	15.40	13.69

DISCUSSION OF RESULTS

First seventy-day period

It may be noted in the summary of results that in rate of gain, in feed consumption for a given unit of gain, and in feed cost, lot III (the coconut lot) gave the best results; lot II (the corn-coconut lot), second; and lot I (the corn lot), third. Lot III made an average daily gain of 0.16 kgm. while lot I made 0.09 kgm., giving a difference of 0.07 kgm., or 78 per cent, in favor of lot III. Lot II made an average daily gain of 0.14 kgm., which was 56 per cent better than lot I.

In feed consumption, lot I required 4.22 kgm. feed to make a kilogram gain; lot II, 2.72 kgm.; and lot III, 2.41 kgm.

As to feed cost for a given unit of gain, lot I required about 20 centavos to make a kilogram gain; lot II, 13 centavos; and lot III, 11 centavos.

Second seventy-day period

In every respect, lot III pigs showed the best results; lot II pigs, second; and lot I pigs, third, ranking in the same order as they did in the first 70-day period. Lot I made an average daily gain of 0.21 kgm.; lot II, 0.22 kgm.; and lot III, 0.35 kgm. Lot III gained in weight 67 per cent more than lot I, and lot II, 5 per cent more.

As to the amount of feed required to make a kilogram gain, lot I required 4.46 kgm.; lot II, 3.94 kgm.; and lot III, 3.05 kgm.

Based on the current prices of feeds during the feeding trial, the feed costs per kilogram gain in weight were about 19 centavos for lot I, 17 centavos for lot II, and 13 centavos for lot III.

Third seventy-day period

Lot III continued to give the best results; lot II, second; and lot I, third. Lot I made an average daily gain of 0.22 kgm.; lot II, 0.30 kgm.; and lot III, 0.41 kgm. With lot I as the basis for comparison, lot II made 36.36 per cent more gain than lot I, and lot III, 86.36 per cent more.

As to feed consumed per kilogram gain, lot I required 5.84 kgm.; lot II, 3.98 kgm.; and lot III, 3.36 kgm.

As to feed cost for a given unit of gain, lot I required 23 centavos worth of feed to make a kilogram gain; lot II, 16 centavos; and lot III, 13 centavos.

It may be observed that, in all the three trial periods, coconut meat effected economies not only by an increase in the rate of gain, decrease in the amount of feed required for a given unit of gain, but also in a reduced cost of the ration, inasmuch as coconut was cheaper than corn.

Three seventy-day periods combined

In rate of gain, feed requirement for a given unit of gain, and feed cost thereof, lot III consistently gave the best results; lot II, second; and lot I, third. It may be seen in the summary of results that the average rate of gain per day for the 210-day period was 0.17 kgm. for lot I; 0.23 kgm. for II; and 0.31 kgm. for lot III. In the amount of feed consumed for a kilogram gain, lot I required 5.01

kgm., lot II, 3.57 kgm.; and lot III, 3.11 kgm.; the cost was 21 centavos for lot I; 15 centavos for lot II; and 14 centavos for lot III.

According to the results obtained, it appears that when the corn in the standard ration mixture (lot I ration) was wholly replaced by fresh coconut meat (lot III ration), the rate of gain was increased by 82 per cent, and when partly replaced (lot II ration), the increase was only 35 per cent. Examination of the ratio of protein to carbohydrates in the rations of lots I, II, and III shows that lot I had the narrowest nutritive ratio and lot III, the widest. One would expect from these figures that lot I pigs would make the most rapid growth, as they were given the ration that had the largest proportion of protein to carbohydrates. The greater gain in weight of the pigs in lot III, however, may be attributed not only to growth but also to fattening during the same period. The pigs of lots II and III were better finished for the market than those of lot I, as shown by their smoother appearance. It is evident that fresh coconut meat is a highly fattening feed.

It is of interest to know the corn-value equivalent of one hectare of coconuts compared with one hectare of corn. According to Copeland (1921)[3], one hectare of coconut produces, on an average, 8,146 nuts a year. According to the finding of Yatar (1934)[4], one hectare of corn gives in one year an average yield of 24,170 ears. The average amount of coconut meat obtained from the 3,620 nuts used in this study was 0.31 kgm. per nut. From one hectare of coconut, therefore, an average of 2,525 kgm. of coconut meat may be obtained. From an ear of corn, according to the finding of Plurad (1934),[5] an average of 0.13 kgm. of shelled corn may be obtained. One hectare of corn, therefore, yields in one year an average of 3,142 kgm. of shelled corn. Now, with the results obtained from the entire period of this feeding test, the amount of feed consumed to make a kilogram gain, when corn was used as a basic constituent of the ration (lot I), was 5.01 kgm.; when fresh coconut was used to wholly replace corn in the standard ration (lot III), the amount required

[3] COPELAND, E. B. 1921. The coco-nut. 2nd ed., xvi + 225 p., 45 pl. London: Macmillan and Co., Ltd.

[4] YATAR, P. Y. 1934. The effects of different rates of application of leunaphos fertilizers on corn. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture. 1934. Unpublished.)

[5] PLURAD, M. B. 1934. The relation of the degree of pollination to the production of covered and exposed tips of corn ear. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture. 1934. Unpublished.)

was 3.11 kgm. Of the 5.01 kgm. feed required by lot I pigs to make a kilogram gain, 1.09 kgm. was corn, and of the 3.78 kgm. feed required by lot III pigs, 1.36 kgm. (0.68 × 2) was coconut meat. Hence, from these results, 1.36 kgm. coconut meat is equal in feed value to 1.09 kgm. of corn, or 1 kilogram corn equals 1.25 kgm. of coconut meat in feed value. The harvest from one hectare of corn, therefore, for pork production has a feed value equivalent to the one year production of 1.54 hectares of coconuts.

It should be noted that the coconuts used in this experiment cost, on an average, ₱0.76 per hundred. The average weight or size of the 3,620 nuts used was 1.17 kgm., of which 26.7 per cent or 0.31 kgm. was meat. It required one hour to prepare grated coconut meat from 20 nuts, using a native hand grater. Excluding cost of labor to prepare the feed, coconut meat cost ₱0.024 a kilogram. When labor is included, the cost per kilogram is increased to ₱0.038. In the computation of the feed cost in this study, labor in the preparation of the feeds, such as cracking corn and grating coconut meat, was not included.

SUMMARY AND CONCLUSIONS

1. With rate of gain in weight as the measure of efficiency, two parts of fresh coconut meat used in place of one part of corn as a basic constituent of the ration used in this experiment was 82 per cent more efficient than corn. When only one-half of the corn in the ration was replaced, the efficiency of the ration was only 35 per cent better than the control lot.

2. Based on the amount of feed required to make a unit gain, the ration containing fresh coconut meat, using twice the amount, was 33 per cent more efficient than the standard ration. When one-half of the corn in the ration was replaced by twice the amount of coconut meat, it was only 27 per cent better than the corn ration.

3. With calculations based on the cost of feed to make a kilogram gain, the fresh coconut-meat ration of lot III was 33 per cent more economical than that of lot I; and when one-half of the corn was replaced by coconut ration (lot II), the economy was 29 per cent.

4. Under the conditions of this experiment, and on the basis of feed required for a given unit of gain, 1.25 kgm. grated fresh coconut meat has a feed value approximately equal to 1 kgm. corn for pigs.

PROTEIN SUPPLEMENTS IN POULTRY RATIONS: IX. STUDIES TO DETERMINE THE BEST COMBINATION OF COPRA MEAL AND FISH MEAL IN RATIONS FOR GROWING CHICKS [1]

DOMINADOR E. EAMILAO

WITH ONE CHART

Fish meal has been found to be an excellent protein supplement in rations for growing chicks. When a comparative study was made on the effects of shrimp meal, fish meal, meat scraps, and tankage in rations for growing chicks, fish meal was found to be a close second to shrimp meal in promoting growth (Fronda, Badelles, and Padilla, 1934). But fish meal has one drawback, which to poultrymen is a serious one, that is, its relatively high cost.

Another chicken feed, copra meal, is reasonably high in protein and is cheap because it is very abundant in this country. But this feed has been found to be unpalatable to chickens (Tuason and Fronda, 1924). Nevertheless, it is tolerated by chicks when it forms from 5 to 20 per cent of the ration (Fronda and Mallonga, 1935).

It is probable that when fish meal and copra meal are mixed in a basal ration for growing chicks, consisting of rice bran and corn meal, a certain satisfactory combination may be obtained. The results of a study made to determine such a combination of copra meal and fish meal in rations for growing chicks are reported in this paper. This experiment was conducted in the poultry laboratory, Department of Animal Husbandry, from October, 1934, to August, 1935.

Review of literature

A few experiments on the feeding value of fish meal and copra meal with different classes of live stock have been worked out in the past in both the Philippines and abroad. But, so far, no experiment has been run to determine the feeding value of fish meal when combined with copra meal in rations for growing chicks.

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[1] Thesis presented for graduation, 1936, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, University of the Philippines; Experiment Station contribution No. 1205. Prepared in the Department of Animal Husbandry under the direction of Dr. F. M. Fronda.

Tuason and Fronda (1924), in a study on the availability and palatability of Philippine poultry feeds, found that shrimp meal was the most palatable of all the ground feeds used, with ground dried fish as a close second, mungo, third, and copra meal, fourth. Francisco, Chan, and Fronda (1934), in a study on the comparative effects of shrimp meal, meat scraps, tankage, and fish meal as supplement in the rations for egg production of Los Baños Cantonese pullets, reported that, in terms of the total number of eggs produced, the shrimp meal lot was the best, followed by the meat scraps, the fish meal, and the tankage lots, in the order named.

According to Fronda and Mallonga (1935), 20 per cent was the optimum amount of copra meal to be incorporated in rations for growing chicks. They further stated that, all factors considered, copra meal is not a good source of protein for growing chicks, and if it is used at all, it should not be more than 20 per cent of the ration.

Mariano (1923) stated that chicks may do well when fed with a ration containing 20 per cent copra meal, provided the ration is supplemented with mungo and meat. Crucillo (1926) reported that copra meal may be used as a supplement in laying rations, provided that it forms not more than 30 per cent of the ration. Taleon (1924), however, found that hens that received no copra meal laid more eggs than those that received 10 per cent copra meal in the ration.

MATERIALS AND METHODS

Los Baños Cantonese chicks were used in this experiment. They were hatched in a 250-egg "Queen" hot-water incubator from eggs laid by the Los Baños Cantonese flock of the College of Agriculture.

Three sets of experiments were run and each set covered a period of three months. In the first set, 96 chicks were divided into six lots of 16 chicks each; in the second, 102 chicks were divided into six lots of 17 chicks each; and in the third, 120 chicks were divided into six lots of 20 chicks each.

All the chicks were raised in fireless brooders kept in separate brooding compartments in the same building. Each brooding compartment had an adjoining grassy run which was accessible to the chicks at all times during the day.

The basal ration used in this experiment consisted of 3 parts by weight of rice bran and 1 part by weight of corn meal. In addition to this ration, varying amounts ranging from 5 per cent to 25 per

cent of fish meal and copra meal, either singly or in combination, were added. The rations actually used consisted of the following ingredients, the figures being parts by weight:

	LOT I	LOT II	LOT III	LOT IV	LOT V	LOT VI
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Rice bran	56.25	56.25	56.25	56.25	56.25	56.25
Corn meal	18.75	18.75	18.75	18.75	18.75	18.75
Fish meal	25.00	20.00	15.00	10.00	5.00	—
Copra meal	—	5.00	10.00	15.00	20.00	25.00
Nutritive ratio [a] .	1:3.2	1:3.6	1:4.1	1:4.6	1:5.3	1:6.1

[a] Based on chemical analysis

The computed composition of the different ration mixtures used is shown in the following tabulation:

	LOT I	LOT II	LOT III	LOT IV	LOT V	LOT VI
	parts	*parts*	*parts*	*parts*	*parts*	*parts*
Moisture	10.10	10.30	10.51	10.71	10.92	11.12
Crude fiber	5.91	7.46	9.03	10.58	12.14	13.69
Ash	9.27	9.57	9.86	10.17	10.47	10.77
Protein	24.94	22.62	20.30	17.98	15.66	13.34
Carbohydrates ..	40.53	40.66	40.78	40.90	41.02	41.15
Fat	9.25	9.39	9.52	9.66	9.79	9.93
Total	100.00	100.00	100.00	100.00	100.00	100.00

The chicks were given an all-mash ration which was self-fed. The feed was placed in open troughs accessible to the chicks at all times during the day. Fresh drinking water was available to the chicks throughout the day.

The chicks, when taken down from the incubator, were leg-banded and weighed individually. They were weighed every week thereafter until the twelfth week. Accurate records of the amount of feed consumed every week by each lot were also obtained. Mortality in each lot was recorded, and minor observations on the vigor and activity of the chicks were made.

RESULTS AND DISCUSSION

Growth of the chicks. The weekly weight of the chicks at different ages was used as criterion in determining the effect of the rations on their rate of growth. The average rate of growth of the chicks up to 12 weeks old in the different lots of the three trials are given in table 1 and chart 1.

By reference to table 1, it may be seen that there was not much difference in the initial weight of the chicks in the different lots. In

the fourth week, the ration of lot II (20 fish meal—5 copra meal) was seemingly better in promoting growth than the ration of lot I (25 fish meal—0 copra meal), the check ration, although, when treated statistically, no significant difference between these two lots was found. In the fourth week, the rank of the different rations with regard to their efficiency in promoting growth of the chicks was as follows: lot II (20 fish meal—5 copra meal), first; lots I (25 fish meal—0 copra meal), III (15 fish meal—10 copra meal), IV (10 fish meal—15 copra meal), V (5 fish meal—20 copra meal), and VI (0 fish meal—25 copra meal).

At eight weeks of age, although lot I (25 fish meal—0 copra meal) and lot II (20 fish meal—5 copra meal) did not show any significant difference, the chicks in lot I weighed a little more than those in lot II. The other lots, however, consistently maintained their former places as regards the mean weight of the chicks.

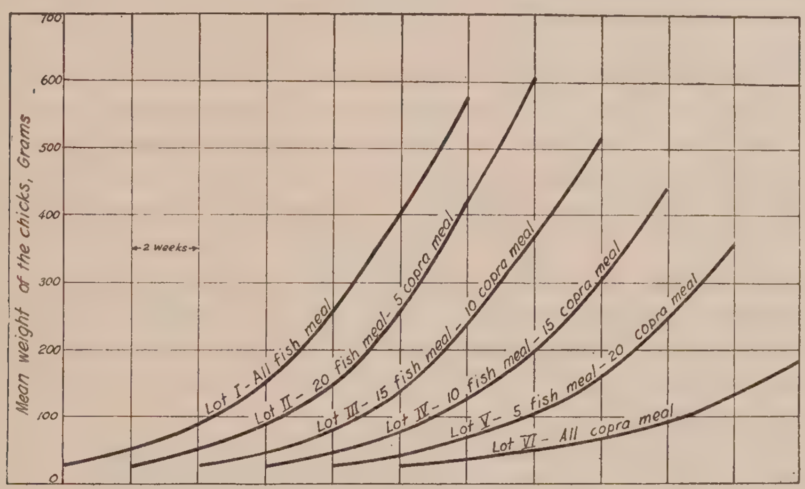

Chart 1.—Curves of the mean weights of the chicks in the different lots studied at different ages

During the twelfth week, insignificant difference was found only between lot I (25 fish meal—0 copra meal) and lot II (20 fish meal—5 copra meal). At the end of twelve weeks, the lot II chicks were the heaviest, and those in lot VI (0 fish meal—25 copra meal) the lightest. The average final weight of the chicks in lot I in this study compares favorably with that reported by Dalid (1935), who used in one of his lots 25 per cent "Lighthouse" fish meal. Dalid reported that the chicks in this lot at 12 weeks of age had an average weight

of 602.6 ± 9.329 grams. In the present study, the lot I chicks that received a ration similar to Dalid's lot, 25 per cent fish meal, averaged 575.9 ± 14.643 grams.

Although at 12 weeks of age lot I (25 fish meal—0 copra meal) and lot II (20 fish meal—5 copra meal) did not show any significant difference, lot II was a little superior to lot I, as shown by the relatively heavier average weight of the chicks. This slight superiority of lot II to lot I was consistently maintained from the ninth week up to the end of the experiment. It may be stated, therefore, that of all the combinations tested in this study, that containing 20 per cent fish meal and 5 per cent copra meal was the best in promoting the growth of the chicks during the brooding period.

It would be interesting to know why the ration in lot II, which consisted of 20 per cent fish meal and 5 per cent copra meal, should give better results in promoting the growth of chicks than the check ration containing 25 per cent fish meal, since weight for weight fish meal has been found to be a better protein supplement than copra meal. It is evident that a larger variety of feeds may, by the law of chance, furnish a better balanced protein mixture than one feed or two feeds alone. The reason is that any deficiency in one feed may be supplemented by another when a larger variety of feeds is used. In this case, it was assumed that receiving the proteins from 20 per cent fish meal and 5 per cent copra meal in the ration of lot II was better than receiving the proteins from 25 per cent fish meal alone in the ration of lot I.

With the mean weight of the chicks in each lot at 12 weeks of age as the basis of comparison, the efficiency of the different rations used was compared. Thus, if the average weight of the chicks in lot II (20 fish meal—5 copra meal), the best of all the lots studied, was considered as 100 per cent, those of the other lots would be as follows: lot I (25 fish meal—0 copra meal), 95.0 per cent; lot III (15 fish meal—10 copra meal), 85.5 per cent; lot IV (10 fish meal—15 copra meal), 72.7 per cent; lot V (5 fish meal—20 copra meal), 59.0 per cent; and lot VI (0 fish meal—25 copra meal), only 30.6 per cent. It may be seen from this comparison that as the amount of copra meal added to the rations increased from 5 per cent, the rations showed a corresponding decrease in efficiency to promote growth of the chicks.

Amount and cost of feeds consumed. When the average amount of feeds consumed per chick during the brooding period of 12 weeks was computed, the following figures were obtained: lot I, (25 fish

meal—0 copra meal) 2.11 kgm.; lot II (20 fish meal—5 copra meal), 2.00 kgm.; lot III (15 fish meal—10 copra meal), 1.84 kgm.; lot IV (10 fish meal—5 copra meal), 1.63 kgm.; lot V (5 fish meal—20 copra meal), 1.39 kgm.; and lot VI (0 fish meal—25 copra meal), 1.16 kgm. With the amount of feeds consumed per chick during the brooding period as criterion for determining palatability, it seems that the addition of copra meal in the rations used in this study made them unpalatable. The greater the amount of copra meal added to the rations, the more unpalatable the rations became.

With the final weights of the weanlings as a base and ₱0.60 as the standard price of these per kilogram live weight, the value of 100 weanlings was found to be highest, ₱36.36, in lot II (20 fish meal—5 copra meal), and lowest, ₱11.10, in lot VI (0 fish meal—25 copra meal). The value of 100 weanlings for the other lots were: lot I (25 fish meal—0 copra meal), ₱34.56; lot III (15 fish meal—10 copra meal), ₱31.08; lot IV (10 fish meal—15 copra meal), ₱26.46; and lot V (5 fish meal—20 copra meal), ₱21.42. The cost of feeds per 100 birds was highest, ₱10.76, for lot I, and lowest, ₱3.71, for lot VI. The reason for this difference is that the chicks in lot I ate the most and the chicks in lot VI, the least. Besides this, fish meal is more expensive than copra meal.

From these figures, it may be seen that the returns above the cost of feeds was highest, ₱26.96, in lot II (20 fish meal—5 copra meal), with lot I (25 fish meal—0 copra meal), ₱23.80, and lot III (15 fish meal—10 copra meal), ₱23.17, as close seconds; and lowest, ₱7.39, in lot VI (0 fish meal—25 copra meal). The results obtained in the present work therefore show that of all the rations tested, that of lot II, which consisted of 20 per cent fish meal and 5 per cent copra meal in addition to a basal ration of 3 parts rice bran and 1 part corn meal, was the most economical. (See table 2.)

Mortality of the chicks. Table 3 shows the percentage of mortality of the chicks in the three trials made. It may be seen from the table that lot VI (0 fish meal—25 copra meal), which had an average mortality of 52.6 ± 0.798 per cent, was the highest, and lot II (20 fish meal—5 copra meal), which had an average mortality of 26.1 ± 2.006 per cent, was the lowest. The high mortality in lot VI in this study corroborates the results reported by Fronda and Mallonga (1935). These authors reported a mortality of 55.5 ± 3.965 per cent in the lot that contained 25 per cent copra meal in the ration.

It is interesting to note that lot II (20 fish meal—5 copra meal) had fewer deaths than lot I (25 fish meal—0 copra meal), the check lot. Since this superiority of lot II to lot I was consistent throughout the three trials of the experiment, it can be stated here that of all the different rations tested in this study, the ration for lot II which consisted of 20 per cent fish meal and 5 per cent copra meal during the brooding period gave the best results in keeping the death rate low.

It may be seen also in table 3 that as the amount of copra meal used in the rations was increased above 5 per cent, the percentage of mortality of the chicks correspondingly increased. The rather high percentage of mortality of lots III (15 fish meal—10 copra meal), IV (10 fish meal—15 copra meal), V (5 fish meal—20 copra meal), and VI (0 fish meal—25 copra meal) must have been caused by the feeds, particularly copra meal. It seems that of the rations tested in this study, those that contained over 5 per cent of copra meal, even if supplemented with fish meal, do not make as good a ration as either the lot I or the lot II ration, in either efficiency to promote growth of chicks or ability to lower the mortality of the chicks.

Health and vigor of the chicks. All the chicks were apparently healthy and vigorous except those in lot VI (0 fish meal—25 copra meal). The chicks in this lot looked pale and emaciated, although they remained fairly active. They seemed to be hungry all the time and were vigorous grazers, always scratching, apparently in eagerness to hunt for food. Evidently, the chicks were not satisfied with the ration given them and so they tried to supplement this with whatever feed they could get on the range. At the close of the experiment, all the chicks were of good size, except those in lot VI, which were rather thin and very small for their age.

Other observations. Early feathering was noticed in the lots in which fish meal formed a part of the rations. The chicks in lots I (25 fish meal—0 copra meal), II (20 fish meal—5 copra meal), and III (15 fish meal—10 copra meal) feathered earliest. At from 6 to 7 weeks old, the chicks in these lots were all fully feathered. The chicks in lot IV (10 fish meal—15 copra meal) and lot V (5 fish meal—20 copra meal) were fully feathered when they were 9 weeks old. The chicks in lot VI (0 fish meal—25 copra meal) were the slowest to feather. Even at the end of the brooding period of 12 weeks, some of them had not yet grown their feathers completely.

SUMMARY AND CONCLUSIONS

A study on the determination of the best combination of fish meal and copra meal in rations for growing chicks is reported in this paper. The rations contained the following: lot I, 25 fish meal—0 copra meal; lot II, 20 fish meal—5 copra meal; lot III, 15 fish meal—10 copra meal; lot IV, 10 fish meal—15 copra meal; lot V, 5 fish meal—20 copra meal; and lot VI, 0 fish meal—25 copra meal. The rest of the ration consisted of corn meal and rice bran in the proportion of 1 to 3. The results obtained may be summarized as follows:

1. Of the different combinations of fish meal and copra meal tested in this study, the combination which contained 20 per cent fish meal and 5 per cent copra meal was observed to be the best. This ration produced the greatest growth with the greatest economy and gave the lowest mortality.

2. With the mean weight of the chicks at 12 weeks of age and the average final weight of lot II, the lot that received the best ration, considered as 100 per cent, the relative efficiency of the other rations was as follows: lot I (25 fish meal—0 copra meal), 95.0 per cent; lot III (15 fish meal—10 copra meal), 85.5 per cent; lot IV (10 fish meal—15 copra meal), 72.7 per cent; lot V (5 fish meal—20 copra meal), 59.0 per cent; and lot VI (0 fish meal—25 copra meal), 30.6 per cent.

3. As the amount of copra meal was increased above 5 per cent, the resulting rations showed a corresponding decrease in efficiency to promote growth and an increase in the mortality of the chicks.

4. The average feed consumption per chick for the whole brooding period was: 2.11 kgm. for lot I (25 fish meal—0 copra meal); 2.00 kgm. for lot II (20 fish meal—5 copra meal); 1.84 kgm. for lot III (15 fish meal—10 copra meal); 1.63 kgm. for lot IV (10 fish meal—15 copra meal); 1.39 kgm. for lot V (5 fish meal—20 copra meal); and 1.16 kgm. for lot VI (0 fish meal—25 copra meal).

5. With the average feed consumption per chick for the whole breeding period as a criterion for determining palatability, lot I (25 fish meal—0 copra meal) ration was found the most palatable, and lot VI (0 fish meal—25 copra meal) ration, the least. The addition of copra meal in the ration made it unpalatable.

6. The returns above the cost of feeds consumed was highest, ₱26.96, in lot II (20 fish meal—5 copra meal), followed closely by lot I (25 fish meal—0 copra meal) with ₱23.80 and lot III (15 fish meal—10 copra meal) with ₱23.17. Lot VI (0 fish meal—25 copra meal) gave the lowest returns, ₱7.39, above the cost of feed.

7. Lot II (20 fish meal—5 copra meal) had the lowest mortality, 26.1 ± 2.006 per cent, and lot VI (0 fish meal—25 copra meal), the highest, 52.6 ± 0.798 per cent.

8. Feathering was earliest in the lots in which fish meal formed a part of the supplement, and latest in lot VI in which the ration did not have fish meal.

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TABLE 1

Average weekly weights of chicks in the different lots for twelve weeks

	LOT I ALL FISH MEAL		LOT II 20% FISH MEAL 5% COPRA MEAL		LOT III 15% FISH MEAL 10% COPRA MEAL	
	Number of chicks	Average weight	Number of chicks	Average weight	Number of chicks	Average weight
		grams		*grams*		*grams*
1 day	53	26.9 ± 0.180	53	27.1 ± 0.186	53	26.9 ± 0.180
1 week	49	37.8 ± 0.687	49	35.4 ± 0.603	48	34.3 ± 0.524
2 weeks	45	49.7 ± 0.922	45	51.3 ± 1.323	44	47.7 ± 0.845
3 "	42	66.9 ± 1.346	42	68.5 ± 2.003	40	59.9 ± 1.161
4 "	42	85.6 ± 2.121	41	87.7 ± 2.528	36	79.0 ± 1.459
5 "	42	114.5 ± 3.157	40	112.0 ± 3.445	36	103.7 ± 2.401
6 "	41	150.2 ± 4.777	40	147.8 ± 4.514	36	136.0 ± 3.165
7 "	40	194.6 ± 7.210	39	195.3 ± 5.859	34	182.5 ± 3.764
8 "	37	258.4 ± 8.720	39	253.8 ± 6.880	34	235.1 ± 4.973
9 "	37	326.5 ± 10.698	39	333.4 ± 9.072	34	300.2 ± 6.089
10 "	37	403.2 ± 12.697	39	422.2 ± 10.788	34	369.1 ± 6.834
11 "	37	486.8 ± 14.303	39	508.9 ± 11.595	34	437.5 ± 7.788
12 "	37	575.9 ± 14.643	39	606.1 ± 12.680	34	518.0 ± 9.292

TABLE 1 (continued)

	LOT IV 10% FISH MEAL 15% COPRA MEAL		LOT V 5% FISH MEAL 20% COPRA MEAL		LOT VI ALL COPRA MEAL	
	Number of chicks	Average weight	Number of chicks	Average weight	Number of chicks	Average weight
		grams		*grams*		*grams*
1 day	53	27.0 ± 0.183	53	27.1 ± 0.192	53	27.4 ± 1.174
1 week	47	33.9 ± 0.558	46	32.6 ± 0.464	42	30.8 ± 0.442
2 weeks	43	45.4 ± 0.895	41	41.1 ± 0.635	39	35.9 ± 0.558
3 "	37	60.2 ± 1.316	38	52.8 ± 0.846	36	43.2 ± 0.618
4 "	33	77.6 ± 1.821	33	66.1 ± 1.228	32	49.5 ± 0.800
5 "	33	97.9 ± 2.569	32	85.2 ± 1.704	31	58.0 ± 1.044
6 "	31	126.0 ± 3.218	32	105.6 ± 2.157	29	68.7 ± 1.256
7 "	31	159.5 ± 4.560	30	127.3 ± 2.562	27	80.9 ± 1.668
8 "	31	195.2 ± 6.082	28	158.6 ± 3.232	27	93.7 ± 2.563
9 "	31	245.3 ± 6.927	28	198.4 ± 4.327	26	109.7 ± 3.534
10 "	31	300.0 ± 8.622	28	248.6 ± 5.988	26	130.4 ± 4.610
11 "	31	368.8 ± 9.775	28	298.1 ± 6.115	25	155.3 ± 5.247
12 "	31	440.6 ± 11.360	28	357.5 ± 7.747	25	185.3 ± 5.261

TABLE 2

Relative cost of production of weanlings of the different lots computed on the basis of 100 birds

LOT NO.	SUPPLEMENTS IN RATION		WT. OF 100 BIRDS	VALUE OF 100 BIRDS	COST OF FEEDS PER 100 BIRDS	RETURNS ABOVE FEED
	Fish meal	Copra meal				
	parts	*parts*	*kgm.*	*pesos*	*pesos*	*pesos*
I	25	—	57.6	34.56	10.76	23.80
II	20	5	60.6	35.36	9.40	26.96
III	15	10	51.8	31.08	7.91	23.17
IV	10	15	44.1	26.46	6.36	20.10
V	5	20	35.7	21.42	4.86	16.56
VI	—	25	18.5	11.10	3.71	7.39

TABLE 3

Percentage of mortality of the chicks for the period of twelve weeks

LOT NO.	TRIALS			AVERAGES
	1	2	3	
	per cent	*per cent*	*per cent*	
I	25.0	29.4	35.0	29.8 ± 1.595
II	18.7	29.4	30.0	26.1 ± 2.006
III	31.2	35.3	40.0	35.5 ± 1.403
IV	31.2	41.2	50.0	40.8 ± 2.994
V	37.5	47.1	55.0	46.5 ± 2.805
VI	50.0	52.9	55.0	52.6 ± 0.798

DESIRABLE LABELS FOR TREES AND SHRUBS[1]

JOSÉ B. JULIANO
Of the Department of Agricultural Botany

WITH ONE TEXT FIGURE

Properly labelling plants is important not only for the purpose of identification but also for reducing to the minimum any possible confusion in observing the leafing, flowering, fruiting, and other similar behavior of individual plants. Besides, these labels may also "educate" one without the aid of a competent teacher, even if the account or information given is very limited. The result from such labels, which may not perhaps be the best, will for the most part be the giving of information more or less detached, uncorrelated, and not purely botanical in nature. The public, on visiting our campus, usually comes for recreation rather than for information, and while this labelling of plants does a real service and meets with genuine and widespread appreciation, it leaves much to be desired. Such effort would be greatly compensated from the standpoint of education, if it does no more than extend the interest of the public in things botanical or serve to give an added interest in life.

In the College of Agriculture, where introduction and acclimatization of exotic as well as indigenous or native and naturalized plants has been going on since its foundation in 1909, attempts to label these plants were made from time to time without much success. As far as the writer can remember, the very first type of labels used in the College in 1919 consisted of pieces of plain G. I. sheet on which the names of the plants were stenciled in black. Later, painted wooden labels were introduced only to be abandoned afterwards owing perhaps to the cost of maintenance and the lack of men to do that work.

Some time in 1929, Dean B. M. Gonzalez suggested to Dr. R. B. Espino, head of the Department of Agricultural Botany (formerly Plant Physiology), that something be done in the matter of labelling our plants on the College campus in a manner similar to, if not better than, those obtaining in some well-known botanic gardens in other

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[1] General contribution from the College of Agriculture No. 576. Received for publication July 21, 1937.

parts of the world. It was, therefore, Doctor Espino, with the aid of Mr. Epitacio Lanuza, then a student assistant in the department and working under the direct supervision of the former, who started the work of making the labels to be described below. In August, 1930, the work was turned over to the writer.

Literature so far consulted has not been able to show that the label described in this paper has been in vogue in the different botanic gardens and experiment stations elsewhere. In the Botanic Garden of the Faculty of Science, Imperial University of Tokyo [2], for example, wooden labels are used, as the pictures contained in their guide book show. According to Dr. Pablo N. Mabbun, of the Department of Agricultural Economics, similar labels are used in Berlin Botanic Gardens. In one of the sugar cane breeding stations in India [3], the labels utilized consist of pieces of wood from packing cases thinly coated with white paint and nailed to bamboo or iron uprights, and these require recoating every year. Ballou [4] recommends for rock plants the use of glass tubes mounted on No. 16 galvanized wire standards. Labels of proper dimensions are typewritten on heavy paper and inserted into these tubes. The slips are then expanded and held closely in contact with the inner surfaces of the glass tubes by a slight filling of tissue paper.

In the Economic Garden of the Bureau of Plant Industry at Los Baños, Laguna, and in the School of Forestry, University of the Philippines, Laguna, wooden labels painted white are used to mark the plants. Although these labels are more attractive and pleasing to the eye at the start, they do not stay long, and repainting is necessary. Besides, the occurrence of an abundance of white ants everywhere in our region adds more to the trouble, and frequent changing of their posts or uprights is necessary. If the labels were nailed directly on the tree, then the use of uprights is not necessary.

The permanent labels (fig. 1) now used in the College of Agriculture at Los Baños, Laguna is rather simple and durable, and each

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[2] Guide to the Botanic Garden of the Faculty of Science, Imperial University of Tokyo. 21 p. illus. 1923.

[3] VANKATARAMAN, T. S. 1920. A few hints on labeling experimental stations. Agric. Jour. India 15: 45–50. *Pl. 4–6.*

[4] BALLOU, F. H. 1935. Weather-proof labels for rock plants. Ohio Agric. Expt. Sta. Bi-monthly Bull. 20 (173): 94–95. *Fig. 1.*

weighs more or less 182 to 312 grams, depending on the thickness of the G. I. sheet used. Each label consists of a rectangular piece of plain G. I. sheet No. 120, measuring more or less 6 inches wide and 9 inches long with its four corners either trimmed obliquely or simply rounded with the use of a pair of shears. This individual sheet piece of galvanized iron is cut from a large plain G. I. sheet No. 120 (size 8 feet × 3 feet) with the use of a steel chisel and a hammer. The piece of G. I. sheet is flattened by hammering its margins with the use of a ball-peen hammer on a large block of hard wood, as molave (*Vitex parviflora* Juss.). On

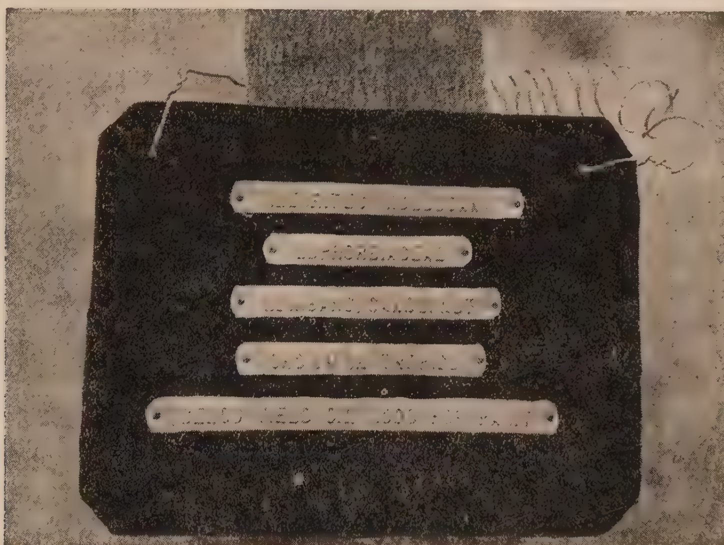

Fig. 1.—Photograph of a plant label *in situ*. Reduced to approximately 3/8 original size

this rectangular piece of plain G. I. sheet are nailed and rivetted pieces of embossed aluminum tape bearing the Latin, family, and vernacular or common names of the plant, its place of origin, distribution, economic uses, if any, dates of planting, and other pertinent data concerning that particular plant to be labelled.

At first the aluminum labels were nailed and riveted with the use of short pieces of brass wire, when the labels were made in the shop of the Department of Animal Husbandry, but the use of brass panel nails, ¾ inch long and manufactured either by Fried. Wild. Schmidt, Harmburg, Germany, or by Tamashina Seiko Sho, Ltd.,

Japan, was found to be more satisfactory. With the former riveting material, a large amount of space of the aluminum tapes is occupied by the brass wire, and the danger of actually destroying the aluminum tapes is more during the riveting process. Holes for nailing and riveting are first made on the piece of plain G. I. sheet with a steel puncher; the brass panel nail is then cut to the desired length. The nail is placed in position with its head resting on a piece of iron and its cut end hammered with a ball-peen hammer to rivet. On the two upper corners of the individual plain G. I. sheet piece are made two holes through which the label is tied to the plant. To make sure that enough galvanized wire is provided for to reduce as much as possible the frequent visits and changes of the wire ties, enough wire should be coiled before finally tying the labels (fig. 1).

Since 1930, the writer has not found much trouble with the labels described above. After a year, the piece of plain G. I. sheet usually shows signs of oxidation at its margins. The label should then be removed from the plant and its edges painted with dehydrated coal tar. During and after painting, however, some of the aluminum labels are often besmirched with the paint. This gives the label a very unsightly appearance. The best way, therefore, to obviate this difficulty is to paint the plain G. I. sheet piece with the coal tar twice before nailing and riveting the aluminum labels. This last method not only provides a good black background to the aluminum labels (fig. 1) but also prevents uneven patches of the paint on the plain G. I. sheet piece.

Owing perhaps to the high relative humidity of the air in our locality, especially during the rainy weather, growth of green unicellular organisms on the unpainted plain G. I. sheet pieces and aluminum labels becomes noticeable as early as six months from the time the labels are placed on the plants. The labels will then need washing and scrubbing at frequent intervals in order to give them their original color and beauty. Painting the pieces of plain G. I. sheet may actually help solve the problem of cleaning the labels once in a while. How long the coal tar paint will stay on the individual pieces of plain G. I. sheet without cracking or falling is a matter of conjecture at present, but it is believed that repainting will be necessary after a much longer time than if other paints, such as white, are used.

It has also been brought to the attention of the writer that some irresponsible individuals while parking near a labelled plant or tree, detach the aluminum labels simply to amuse themselves. Very often, a label can be found thrown away and its wire tie removed by someone. Holes are sometimes made through the plain G. I. sheet piece in an attempt perhaps to use it as a target in a pistol or rifle practice. These minor troubles could be easily avoided and prevented if every one would coöperate in making the public conscious of the benefits derived from them.

In labelling plants, the question of cost and maintenance is a matter of import. Attempt is made here to present the data given below for the information of those interested in labelling their plants and in adopting the method herein reported. It has to be remembered that prices of the materials listed below may vary from time to time and from place to place, and while the figures may be true at the time the data were gathered, they may not hold true at all later. The figures in hours represent averages of the performances of five student laborers who have worked directly under the supervision of the writer since 1930.

TABLE 1

Bill of materials

ITEMS	CURRENT PRICE	NUMBER OF LABELS
	pesos	
One sheet plain G. I. (size 8 feet × 3 feet) obtainable from any hardware store in Manila	2.70	Makes 40 labels or plane G. I. sheet pieces
One can dehydrated coal tar (5 gallons) obtainable from the Manila Gas Corporation, Manila	1.19	Paints (2 coats) on 240 labels
One roll aluminum tape (41.21 meters) obtainable from J. P. Heilbronn Co., Manila	3.00	May be used for 41.2 labels
One package panel brass nails, ¾ inch (2,057 nails) manufactured by Fried. Wild. Schmidt, Hamburg, Germany	0.85	May be used for 114.3 labels

Table 2 shows the labor required in making the 40 labels which can be obtained from one large sheet of plain G. I. No. 120.

TABLE 2

Labor requirements per sheet plain G. I. or 40 labels

ITEMS	HOURS
Cutting the plain G. I. sheet pieces	5
Trimming corners of plain G. I. sheet pieces	3
Flattening plain G. I. sheet pieces	4
Painting plain G. I. sheet pieces	
First coat	2
Second coat	3
Embossing aluminum labels	13.33
Nailing and rivetting aluminum labels	11.42
Total	41.75

From tables 1 and 2, the cost of making a single label described above was computed, as shown in table 3.

TABLE 3

Computed cost of making one label

ITEMS	COST	
		pesos
Plain G. I. sheet piece		0.06750 [a]
Coal tar paint (two coats)		0.00496
Brass panel nails		0.00743
Aluminum tape		0.07279
Labor:		
Cutting one label	0.01250	
Flattening and trimming	0.01750	
Painting (two coats)	0.01250	
Embossing	0.03333	
Nailing and riveting	0.02857	0.10440
Total		0.25708

[a] Wage per hour of a student laborer in the College of Agriculture is ten centavos (₱0.10).

To the computed cost of approximately ₱0.26 per label, as shown above, should be added the cost of the plain galvanized wire tie needed in placing each label on the individual plant and the amount of time consumed by the laborer in tying the same label on the plant. In the computation of the approximate cost of making labels described above, the personal element has to be taken into account. For example, a very experienced and diligent laborer with sufficient dexterity can reduce the cost of each label very considerably, while a poor one will inevitably increase its average cost.

At present, we have 1,319 such labels on permanent trees and shrubs in the College of Agriculture campus, and while the cost of making them and their maintenance may be quite high, still the benefits to be derived from them are immeasurable, as the favorable verbal comments from various foreign and local visitors bear out. It is the fervent hope of the writer that time will not be far distant when practically every species of plants occupying our campus will be similarly labelled.

A REVIEW OF RECENT WORK ON SOIL CLASSIFICATION IN THE PHILIPPINES [1]

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The importance of soil survey, both reconnaissance and detailed, is a subject which has been much discussed. Dawson (1937), an agricultural expert who visited the Islands in May, commented on the pressing need of our country along agricultural lines. He stated that "A general survey under way should be pressed to completion with the greatest possible speed to give a basis for crop planning."

Early work. During the Spanish régime the attention of the early investigators was directed into the field of geology and mineralogy. Through the efforts of the early geologists, especially the foremost Spanish geologist, Abella y Casariego, whose works appeared between 1879 and 1893, José Centeno, Richard von Drasche, and a few others, a large mass of information on the subject was left to us at the close of Spanish rule. From published literature, it appears that the study has received serious attention only since the middle of the nineteenth century.

At the beginning of the American occupation Becker (1901) summarized the Spanish contributions to Philippine geology. Twenty-three years later Smith (1924) presented a more thorough résumé of the subject.

The work on soils (pedology) only started thirty-five years ago when Dorsey (1903) surveyed the soils of the Batangas area. He defined seven series of agricultural soils. The eighth group consisted of non-agricultural soils. The series names, following the U. S. Bureau of Soils, were taken after the places—town, barrio, mountain, or river—where such characteristic soils were first found. Thus, Dorsey's soil series were: (1) Ibaan, (2) Lipa, (3) Taysan, (4) Malabo, (5) Macolod, (6) Talumpoc, and (7) Calumpang. The non-

[1] General contribution No. 577. Received for publication September 10, 1937. The author takes this opportunity to acknowledge his indebtedness to Dr. D. I. Aquino for his valuable suggestions during the preparation of this manuscript.

agricultural soils consisted of muck and salt marsh. These soil series, found in an area of 48,400 hectares, were represented by eleven soil types delineated on a scale of 1:63,400.

The most energetic work on soil survey begun by Dorsey in the Philippines was followed by a lull of two or three decades. This period of inactivity was due to the apparent lack of interest on the part of the then Bureau of Agriculture to continue Dorsey's work. The Bureau of Science directed its attention to the chemical and physical aspects of the study of soils.

One of those who started the studies of the chemical and physical characteristics of the soils of the Philippines was Walker (1910). He made an extensive chemical and physical study of the sugar cane soils of the island of Negros. Cox and Argüelles (1914) studied soils under sugar cane culture and concluded that the agricultural value of the soils is determined, not only by their chemical composition, climatic and other conditions, but also by their physical characteristics.

Resumption of soil survey. The College of Agriculture, University of the Philippines, instituted soils courses in our curriculum in 1920 and has since then kept a live interest in this phase of soil science (pedology).

Pendleton (1927) who took charge in 1923 of the Soils Division—now Department of Soils—published the second work on soil survey. This work was financed by the Hawaiian-Philippine Company. His investigation covered 23,800 hectares of the Silay-Saravia area, delineated on the scale of 1:50,000. He mapped three soil series, namely, (1) Guimbala-on, (2) Silay, and (3) Guintabu-an. The non-agricultural soils consisted of riverwash, coastal marsh, tidal land, and fish pond.

In 1931, he reported the third work on soil survey, also financed privately. The results of the soil survey of 39,018 hectares of La Carlota area were released. He delineated on a working scale of 1:4,000 eleven soil series, three of which were the same series found in the Silay-Saravia area. The eight new series are as follows: (1) Legua, (2) La Castellana, (3) San Jose, (4) La Carlota, (5) Kamandag, (6) Bago, (7) Isabela, and (8) Pulupandan. The non-agricultural soils mapped consisted of four groups: stony, steep, and mountainous; ravines and eroded stream banks; mangrove and nipa marshes; and riverwash.

College of Agriculture theses.[2] Since 1927, soil survey studies in the form of theses have been conducted in the College of Agriculture. The twenty theses on soil survey thus far completed contain a mass of data regarding the soil resources of the Maquiling area.[3] Seven theses on subjects related to soil survey were also finished and presented in 1925-1928. All of these unpublished theses are available for reference in the library of the College of Agriculture.

Bandong made a study of the origin of tuff soils. The mode of formation of soils from volcanic tuff was the subject of Carulla's study. The soils of Maquiling area are essentially sedentary from volcanic tuff and ash.[4] Durano studied the drainage characteristics of some soils in the College of Agriculture Experiment Station. Quizon, Villar, Yasay, and Briones made separate studies on the profile characteristics of some soils in the Maquiling area, particularly the soils of the Experiment Station, College of Agriculture.

The first theses on soil survey were presented in 1929 by Andrada, Mejia, and Jacomina. They mapped portions of the municipalities of Calamba, Los Baños, and Bay. They classified the soils as alluvial or residual.

Jain and Agustin conducted soil surveys in 1930 of La Carlota sugar central district. Part of their results is incorporated in the published paper on La Carlota area by Pendleton (1931).

In 1931, five students, Cero, Bernardo, Quiaoit, Reynes, and Erce, surveyed the Maquiling area of about 23,775 hectares consisting of Alaminos region, Santo Tomas region, Mamatid-Nanhaya area, Calauan area, and Tanauan region. (Note: The soil areas

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[2] *Theses on soil survey*

1929. Amado A. Andrada, Agustin J. Mejia and Pedro G. Jacomina
1930. Porfirio E. Jain and Leodegario N. Agustin
1931. Magdaleno M. Cero, Fernando Bernardo, Gregorio F. Quiaoit, Cosme O. Reynes, and Pedro P. Erce
1934. Restituto P. T. Felipe, Laureano R. Lucas, Melecio P. Baltazar, Ambrosio P. Cacayan, Ambrosio P. Bayan, Santos Antonio Belo, Francisco L. Calimbas, Domingo Siapno, Francisco B. Lopez, and Glicerio A. Pescador

Theses on subjects related to soil survey

1925. Pablo Z. Quizon
1926. Tomas Bandong and Edmundo G. Yasay
1927. Antonio Durano and Ulpiano A. Villar
1928. Alfonso Q. Briones and Ignacio E. Carulla

[3] The results of the individual soil surveys are now being put together by the Department of Soils, College of Agriculture.

[4] The geologic characteristics of the Maquiling area were studied by Abella y Casariego (1885) and Adams (1910).

studied by Andrada, Mejia, and Jacomina in 1927-1929 are also included in the Maquiling area.) They delineated the soil types on a scale of 1:31,680 (about 1/3 kilometer to the centimeter). The five students reported the soils of the Maquiling area similar to the soils of the Batangas area as to origin, mode of formation, topography, and relief. Hence, four of the five soil series they mapped were the same as the series defined by Dorsey twenty-eighth years before. The series mapped were (1) Ibaan, (2) Lipa, (3) Macolod, (4) Calumpang, and (5) Bay. Bay series is a new soil series; Qüiaoit first defined and mapped it. The non-agricultural soils consisted of "puting lupa" (white soil), exposed tuff, gravel, and sand.

Thus far, the soil surveys had been conducted on very small scales, about 1/3 kilometer to the centimeter; the very fine details could, therefore, not be shown. A detailed soil survey of the area on a large scale, say 1:1,000, or 10 meters to the centimeter, was then necessary to show the minute details. The results of such survey become a valuable guide in soil management. Thus a detailed soil survey of the Maquiling area was begun, starting with the College of Agriculture grounds and adjoining private lands. A total area of 1,220 hectares was surveyed on a scale of 1:1,000 in 1934 by nine thesis students, Felipe, Lucas, Baltazar, Cacayan, Bayan, Belo, Calimbas, Siapno, and Lopez. Minute details were shown in the delineation of the soil types into phases. For example, soil type *Lipa clay loam* was mapped as *L. C. L. shallow phase, L. C. L. medium phase,* or *L. C. L. deep phase.* They mapped six soil series, two of which were delineated for the first time. The series are: (1) Ibaan, (2) Lipa, (3) Macolod, (4) Calumpang, (5) Los Baños, and (6) Nanhaya. Lopez first described Los Baños series, and Felipe, Nanhaya series.

Pescador, another thesis student, reported his work in 1934 on the soil survey of Pila, Laguna.

Of the three series which are defined for the first time in the College theses, only Nanhaya series was reported. Barrera (1937) used soils belonging to this series in his work. Pendleton and Aquino (1932) in their study of the soils of Bokakeng forest management project near Baguio, Mountain Province, established two soil series: (1) Baguio and (2) Mirador.

Current reconnaissance survey in the Philippines. Java, Indo-China, the Federated Malay States, Japan, and, lately, China have

gone far in soil survey work. The need of such project in the Philippines was essentially realized by our government. In 1934, the Secretary of the Department of Agriculture and Commerce assumed responsibility for undertaking a reconnaissance survey of the Philippines. Accordingly, he appointed a committee on Philippine soil surveys with the Under-Secretary as chairman and the directors of the Bureaus of Science, Plant Industry, Forestry, Lands, and Weather as members. The work is being undertaken by personnel of the Bureau of Science and Bureau of Plant Industry, with Dr. M. M. Alicante in charge of the project.

To date, the committee has surveyed thirteen provinces. So far only the results of the reconnaissance surveys of Bulacan and Rizal provinces are in print. For Bulacan province nine soil series were defined and delineated: (1) Bulacan, (2) Obando, (3) Quingua, (4) Bigaa, (5) Bantog, (6) Prensa, (7) Novaliches, (8) Buenavista, and (9) Sibul. For Rizal province ten soil series were mapped. Four series, Obando, Quingua, Prensa, and Novaliches, are the same as those mapped in Bulacan province. The other six series which were defined for the first time are: (1) Rizal, (2) Guadalupe, (3) Mariquina, (4) Bay, (5) Binangonan, and (6) Antipolo. The Bay series was also mapped in the Maquiling area in 1931. The plain provincial maps with a scale of 1:100,000 prepared by the Bureau of Public Works were used as base maps.

Extent of soil survey in the Philippines. At present, about 605,000 hectares, or only two per cent of the total area of the Philippines, have been reported as surveyed. Of course, there is a large area now surveyed but the results have remained unpublished. The College of Agriculture has data for 25,000 hectares of the Maquiling area and the Department of Agriculture and Commerce has many of the results of its reconnaissance survey work not as yet released for publication.

The following table shows the extent of the soil survey work in the Philippines thus far. It may be seen in this table that the detailed soil surveys are those conducted in the College of Agriculture on a very large scale of 1:1,000 and by Pendleton (1931) on a scale of 1:4,000. The other surveys are reconnaissance work.

The extent of the soil survey work in the Philippines[a]

AREA	YEAR	SURVEYED BY	NO. OF HECTARES	SCALE
Batangas area	1903	Dorsey	48,400	1:63,400
Silay-Saravia area	1927	Pendleton	23,800	1:50,000
La Carlota area	1931	Pendleton	39,018	1:4,000
Maquiling area[b]	1931	College of Agriculture theses	23,775	1:31,680
College of Agriculture and adjoining lands	1934	C. A. theses	1,220	1:1,000
Bulacan province	1936	Dept. of Agriculture and Commerce	260,800	1:100,000
Rizal province	1937	Dept. of Agriculture and Commerce	232,915	1:100,000

[a] Unreported work of the Department of Agriculture and Commerce is not included in this table.
[b] Area italicized shows the work is unpublished.

SOIL SERIES DESCRIBED

The soil type is the unit of soil classification. It has definite characteristics not wholly duplicated by any other type. For example: Lipa clay loam, Los Baños clay loam, and Ibaan clay loam are all clay loam as far as their texture is concerned, but Los Baños is steep and rolling in relief while Lipa and Ibaan are generally flat or very slightly rolling. Ibaan differs from Lipa in its profile; Ibaan soils are characteristically shallow, whereas Lipa soils have deep surface and subsoil. Hence, calling our soil by its texture alone does not exactly identify it; it is somewhat like calling rice just *sativa*.

In the following pages will be given brief descriptions of the soil series so far reported in the Philippine Islands.

Batangas area

Seven soil series were described: Ibaan, Lipa, Taysan, Malabo, Macolod, Talumpoc, and Calumpang.

Ibaan. A large area of land about the town of Ibaan was named Ibaan clay loam.

> Profile—surface soil average depth 12 cm.; reddish brown in color; tenacious, difficult to till and cultivate; hard firmly baked clods found in plowed fields.
>
> Subsoil—average depth 30 cm. from the surface; heavier in texture than surface soil; more reddish in color, and at lower depths just above the underlying tuff, color grades into gray and brown as the underlying tuff. Soil is so characteristically shallow that in many places even shallow plowing brings to the surface broken bits of tuff. In some favorable places, however, the surface and subsoil may measure as deep as 80 cm.
>
> Relief—generally level or gently rolling; broken at certain portions.

Drainage—fair to good. Except when rainfall is heavy, artificial drainage is unnecessary.

Origin of soil—residual from the underlying tuff.

Lipa. The soils bearing this name were first found about the town of Lipa. Only one type was delineated.

Profile—surface soil average depth 25 cm.; dark brown, rich-looking mellow, easy to cultivate; generally fertile.

Subsoil—rather deep, even exceeds 1 meter from the surface; darker in color than surface; loamy in texture but becomes heavier and waxy at 75 cm.

Soil is characteristically deep and gives evidence of lasting fertility.

Relief—generally level or slightly rolling like Ibaan.

Drainage—fair to good like Ibaan; erosion very slight.

Origin—also residual from the decomposition of the underlying volcanic tuff.

Taysan. The soils described under this name occupy a large area about the town of Taysan and Rosario. Taysan series is similar to Ibaan and Lipa in topography but differs in the profile, especially in the consistency of the soil mass. Only one type was delineated—Taysan clay.

Profile—surface soil average depth 16 cm.; heavy black clay; tough and tenacious with a tendency to bake hard; cracks formed when dry.

Subsoil—average depth 35 cm. from surface; tough; black and sometimes lighter in color than surface soil; very impervious to a free passage of water.

In some places depth of surface and subsoil may exceed 1 meter and in some cases the underlying rocks may be found about 20 cm. from the surface.

Drainage—poor, owing to the difficulty of water movement in the soil. During the rainy season large areas are covered with water which drains very slowly.

Poor drainage and the decay of rank growth of grass over long periods of years are attributed as responsible for the black color and almost mucky condition of the soil.

The relief and origin of this soil are similar to Ibaan and Lipa.

Malabo. Malabo waxy clay was the only type mapped. This series differs from the three just described principally in the source of the soil.

Profile—surface soil to a depth of 45 cm. is rich black, waxy clay; its waxy character distinguishes it from Taysan clay.

Subsoil—deep, very little difference from surface except that in some places it grades into soft, yellowish clay. Under subsoil is partially decomposed limestone.

Relief—rough, broken region and slopes of mountains.

Drainage—well drained on account of the rolling mountainous character of the topography.

Origin—soil residual like Ibaan, Lipa, Taysan but is derived from decomposition of hard crystalline limestone or marble.

Soils derived from pure limestone are generally rich and fertile and Malabo waxy clay is not an exception to this rule. Malabo soils have lasting fertility and "readily repay the extra cost necessary to thoroughly prepare them before planting."

Macolod. This soil was first found on the slopes of Mount Macolod and on some smaller peaks.

Profile—very much like the Ibaan soils; surface soil average depth 15 cm.; brown, tenacious with admixture of fine gravel. On the more steep slopes black, andesitic rocks are exposed. Soil covering is thin due to excessive erosion.

Topography—characteristically steep and mountainous. Erosion excessive. This explains why the soil covering is thin.

Drainage—very excessive.

Origin—derived from slow decomposition of the underlying rocks; hence, no great accumulations can take place.

Talumpoc. The soils belonging to this series occupy a large area about the barrio Talumpoc. They are derived from the decomposition of solid red and black andesites.

Profile—surface soil characteristically shallow, average depth 10 cm., in some places 5 cm. deep while in others 20 cm.; rather hard, compact; black in color.

Relief—area is rough, mountainous with deep, narrow valleys and small turbulent streams.

Drainage—excessive.

Origin—residual from decomposition of volcanic materials which consist of hard granular tuffs, and solid red and black andesites; decomposition of rocks slow and erosion excessive; hence no great accumulation of soil can take place.

Calumpang. The soils belonging to this series are alluvial deposits, typically represented by that group of soils in the plain between the Calumpang River and Batangas Bay. Three soil types were found. The soils are generally fertile.

Profile—surface soil average depth 20 cm.; heavy, dark-colored, stiff; bakes badly when wet; large clods formed which can be broken with difficulty.

Subsoil—average depth 60 cm.; waxy; black which grades into a yellowish color.

Topography—flood plains; quite level; wide terraces formed.

Drainage—very good.

Origin—alluvial soil; accumulations of fine sediment deposited by the stream in shallow water and in the flood plains.

Maquiling area

Four of the seven soil series mapped in this area are the same series defined and delineated in the Batangas area; they are Ibaan, Lipa, Macolod, and Calumpang. The other three series [5] are Nanhaya, Los Baños, and Bay.

Nanhaya. Only one type was mapped and it is called Nanhaya clay. Nanhaya series consists of soils that stand in between Lipa and Calumpang as far as their origin is concerned.

> Profile—surface soil depth ranges between 20 and 40 cm.; dark grayish brown to dark brown clay; sticky and plastic.
> Subsoil—depth about 1 meter from surface; dark brown to yellowish brown; waxy and sticky; mottled red with occasional fine gravel.
> Topography—level. Drainage—good.
> Origin—derived from the decomposition of the underlying tuff and accumulation of transported materials.

Los Baños. The soils of this series are intermediate between Lipa and Macolod in topography.

> Profile—surface soil ranges from a few centimeters to 35 cm. depth; light brown to brown in color.
> Subsoil may be tuff itself. When subsoil is present, it is heavier in texture and lighter in color than surface soil; depth extends to as far as 90 cm.
>
> Topography—very irregular, rolling but not as steep as Macolod; streams produce wide cuts.
>
> Drainage—excellent to excessive. Erosion heavy; often truncation results.
>
> Origin—the same as Ibaan, or Lipa, where soil is residual from the decomposition of volcanic tuff and ash.

Bay. A narrow strip of agricultural land along the shores of Laguna de Bay was classified under Bay series. The soils of this series consist of an accumulation of sediments which had been carried into the lake by streams and washed and worked over into the present location by wave action. The soil is fertile.

> Topography—generally flat.
>
> Drainage—very poor because area lies below high water level of lake; usually submerged for months during the rainy season.

Bokakeng forest management project

The soils of the Bokakeng area, located near Baguio, Mountain Province, are much influenced by their geological origin and by the treatment that man has accorded them. There was a practice in

[5] The three soil series, Nanhaya, Los Baños, and Bay, will be reported on when the results of the soil survey of the Maquiling area are published by the Department of Soils, College of Agriculture.

which the forest litter was raked and burned in order to obtain the ash for fertilizer. The area "lies on the coralline limestone of the Malumbang formation (Pliocene) and on andesitic breccias and tuffs of the Baguio formation (late Pliocene)."

Baguio. The soils described under this series are forest soils. The original trees were logged off; now the area is covered with pine tree seedlings under the management of the Bureau of Forestry.

Profile—surface soil 10 to 35 cm. deep; two phases exist: the dark phase and light phase; dark phase, soil dark brownish gray to black when moist, light phase dark brown to brownish red when moist, and light brown, grayish brown, reddish brown when dry.

Subsoil—yellowish brown, light brown, or dark brown for the dark phase; red, with some light brown or reddish brown or brownish red for the light phase.

Topography—rolling to very steep, irregular, rough.

Drainage—excessive; as a result serious erosion takes place in portions cultivated by the natives.

Origin—derived from the andesites and tuffs of the pyroclastics of the Baguio formation.

Mirador. The soils belonging to this series are also forest soils. The chief difference of this series from Baguio series lies in the origin of the soil. Outcrops of jagged limestone are visible on the surface of the Mirador soils.

Profile—surface soil variable in depth, usually 10 to 20 cm.; grayish brown, or dark grayish brown to black.

Subsoil—brown, light brown or light yellowish brown. Red color is associated with soils weathered from pyroclastics, but not with soils from limestone.

Topography—rounded hill tops and steep slopes.

Drainage—excessive; erosion serious.

Origin—largely residual from the weathering of limestone of the Malumbang formation. Some places are overlaid with fragments of andesites and tuff where red color is produced.

Silay-Saravia area

The Silay-Saravia area is located in Occidental Negros. Three soil series were defined and mapped.

Guimbala-on. The soils belonging to this series consist of old alluvial fan in the highland area. The alluvial deposits are of old age as indicated by the presence of rocks completely weathered, their composition and hardness being greatly changed. The deposits were made by swift streams, as shown by the presence of bowlders and large-sized gravel.

Profile—surface soil of moderate depth, not more than 25 cm.; brown to dark brown or reddish brown.
Subsoil—rather deep reaching in places to 1 meter; lighter in color and slightly heavier in texture than the surface soil.

Topography—highland, undulating to rolling or sloping; ravines and deep cuts by stream channels present.

Drainage—excessive; portions of the area considerably eroded.

Silay. The Silay soils are on the lowlands; they consist of recent alluvial deposits coming from the highlands (Guimbala-on soils) and mountains as a result of erosion.

Profile—surface soil average depth 25 to 30 cm.; brown to grayish brown or brownish gray or dark gray; some portions occasionally mottled with brownish, bluish, or blackish tinges.
Subsoil—varies between 50 and 100 cm. from surface, but in certain small areas depth extends to even 200 cm.; brown or grayish brown mottled with bluish or brownish spots, and some brownish concretions.

Topography—very slightly irregular, flat or nearly so.

Drainage—usually poor. Artificial drainage is necessary to make the land useful to such crops as sugar cane.

Guintabu-an. The soils of this series are believed to be volcanic ash soils. Locally, they are known as "abo-abo" soils. They are rather infertile because of the presence of loose gravel in the subsoil.

Profile—surface soil 15 to 30 cm. deep; very dark gray to black in color; loose and fluffy.
Subsoil—about 50 cm. deep from surface; loose gravel and cobbles are present; much lighter in color than surface soil.

Topography—slightly rolling and irregular. It is intermediate between Guimbala-on and Silay.

Drainage—fair to good.

La Carlota area

La Carlota area is located in the same province as the Silay-Saravia area. Consequently, there are soils in both areas that are similar. Guimbala-on, Silay, and Guintabu-an series are also found in this area.

Legua. This series resembles in several ways Guimbala-on, but differences in topography are sufficient to separate them into two distinct series. The soils are moderately deeply weathered.

Profile—surface soil about 20 to 30 cm. deep; brown to dark brown or dark brownish gray. Soil appears reddish brown from a distance.
Subsoil—lighter in color than surface soil.

Topography—occurs on steep hills: on hilltops and hill sides. Occasionally, large hard andesitic-basaltic boulders appear.

Drainage—excessive and erosion serious.

Origin—soil is "residual occurring upon irregularly rounded to rather steep hills and slopes, on material apparently carried out originally as lahars or mud flows from Canlaon volcano."

La Castellana. The soils of this series are believed to have been the result of volcanic ash fall of very fine material which covers the hills. La Castellana is similar to Legua in topography, but it differs in the profile characteristics.

Profile—surface soil uniform in depth 15 to 30 cm.; dark grayish brown or grayish in color when dry; brownish gray or dark brownish gray when moist.

Subsoil—similar to subsoil of Guimbala-on; deep, variable from less than a meter to several meters from surface; color mainly brown, varying to a dark grayish brown or a light brown with a mottling of red in some places; deeper subsoil occasionally is quite red and contains iron concretions.

Topography—occurs on slopes of steep hills of volcanic tuff, breccia, and larger igneous boulders on rolling tracts and nearly flat areas. (Similar to Legua).

Drainage—excellent to excessive; erosion continually removes the surface soil.

San José. The soils of this series seem to be the result of a deposit of more recent volcanic material over the older material, the Guimbala-on soils. Hence, on the whole the subsoil of San Jose soils possesses the characteristic soil of the Guimbala-on series, both in texture and color.

Profile—surface soil 25 cm. deep; loose and dusty; very dark brownish gray to a dark gray or true blue black when dry; when moist dark brownish gray to black.

Subsoil—medium brown, or light brown, speckled; contains considerable gravel below.

Topography—similar to Guimbala-on; old alluvial fans and lahars, deeply dissected due to stream erosion.

La Carlota. This series seems to be intermediate between Guimbala-on and Silay; there is a transition between the brown distinctly upland of Guimbala-on and the gray distinctly lowland of Silay. La Carlota soils are water deposits.

Profile—surface soil 15 to 30 cm. deep; brown, grayish brown, light grayish brown to gray; browner or redder color develops on the older, higher well-drained portion of the series; considerable iron concretions present.

Subsoil—extends to about a meter from surface; brown grayish brown or slightly lighter in color than surface soil; deeper subsoil is slightly lighter in color, often heavier in texture.
Substratum—compacted layer of hardpan present about 1 meter deep from surface.

Topography—intermediate between the highlands of Guimbala-on and lowlands of Silay.

Drainage—fair; in some places poor.

Kamandag. The soils of this series are characterized by the presence of a considerable amount of iron concretions. They are of old alluvial material, occurring typically lower in topography compared to all the other series. They are thoroughly weathered, exceeded only by Bago series.

Profile—surface soil varies from 15 to 30 cm.; brownish gray, dark brownish gray or grayish brown, with a considerable amount of iron concretions.
Subsoil—varies from reddish brown to brownish gray. In some places, a continuous hardpan of cemented limonite concretions, often present about half of a meter from the surface, is found.

Topography—occurs lower topographically than the other series; land rolling or sloping to nearly flat with numerous ravines running through the area. Because of the low location there is a fair supply of seepage and run-off water.

Drainage—fair to excessive.

Bago. The soils of this series are thoroughly weathered. Like the Kamandag soils, the Bago soils also contain iron concretions but their profile characteristics differ rather widely. The soils look rather infertile.

Profile—surface soil, rather shallow from 15 to 20 cm. deep; gray in color; usually underlain by a zone 5 cm. in thickness which contains iron concretions; next zone is plastic, whitish clay. Deep plowing brings to the surface the iron concretions and the plastic clay, thus the texture of the tilled portion of the area is greatly altered, becoming moderately heavy.
Subsoil—the plastic impermeable clay layer constitutes the subsoil. Color, light gray to bluish gray.

Topography—area is higher than surrounding soils of other series; nearly level or slightly undulating, cut by numerous ravines.

Drainage—good in surface soil; while in subsoil, poor because of the presence of the zone of plastic clay.

Origin—the original soil is believed to be lying in coastal swamps, covered with brackish water along the shores of the island.

Isabela. Isabela soils occur on level land. They are characteristically deep and uniform.

Profile—surface soil rather deep, sometimes reaching 80 cm.; dark gray when dry and very dark gray or black when moist; moderately friable.

Subsoil—depth reaches to more than 1 meter from surface; dark gray or black, or mottled with bluish and grayish or yellowish color.
Substratum—yellowish, or brownish mottled heavy clay loam.

Topography—flat, and area is low-lying.

Drainage—fair to poor on account of flat topography.

Pulupandan. This series distinguishes itself from the other series in its mode of formation. The soils belonging to it are typical coastal beach deposits. Therefore, one should look for these soils along the seashore.

Profile—surface soil usually from 22 to 35 cm. deep; dark brownish gray with mixture of marine shells.
Subsoil—mixture of soil and considerable amount of broken shell fragments; hence, subsoil forms whitish layer; layer reaches a depth of 1 meter or more.

Bulacan Province

The Department of Agriculture and Commerce releases the results of its reconnaissance survey of the Philippines by provinces through its publication, the *Technical Bulletin.* (For Bulacan province, Tech. Bull. 5, and for Rizal province, Soil Report 2, or Tech. Bull. 9).

At the time of this writing, many of the Department's reports are in press. In the following descriptions only the conspicuous characteristics of the various series defined by the Department will be touched.

Island and basin soils. These soils occupy the region bordering Manila Bay. Two series were identified and defined: *Bulacan* and *Obando.* The soils belonging to Bulacan series are submerged and are located along the braided streams and rivers and in swamps. Obando soils are also situated in low places but are not under water. These soils are distinguished from Bulacan soils by the presence of marine shells in the lower subsoil.

Alluvial fans and plain soils. Three soil series were identified and defined: Quingua, Bigaa, and Bantog. The soils are of recent alluvial deposit; no true profile development is shown. The soils possess reddish brown streaks, which are characteristic of the lowland rice-field soils. The relief is generally flat and low. Consequently, the soils have poor drainage; often, during the rainy season, the area remains under water for two to three months.

The soils belonging to *Quingua* series are light brown to light reddish brown; the subsoil is light-textured. The surface soil is generally loose;

depth ranges from 25 to 40 cm. The subsoil is somewhat compact, characterized by light brown heavier material; in some portions loose and friable. The *Bigaa* soils have brown to dark brown surface soil with notable reddish brown or dark yellowish brown streaks. The subsoil is light gray to dark brownish gray, mottled with yellowish or reddish brown. In both surface and subsoil concretions are present. The depth of the surface soil is 20 to 30 cm. and the subsoil, 40 to 100 cm. from the surface.

The soils of *Bantog* are similar to Bigaa. The difference lies in the absence of concretions in the surface and subsoil. The surface soil ranges from 25 to 30 cm. deep.

Upland and mountain soils. Four series (Prensa, Novaliches, Buenavista, and Sibul) were mapped. The soils of these series are sedentary from the weathering of the underlying rock. The soils are upland; the relief of the land is from slightly rolling to hilly. Drainage is good to excellent.

Prensa. The surface soil is friable and granular, light brown, brown to reddish brown. It varies in depth from 15 to 25 cm. The subsoil is also friable and granular and has a large amount of gravel and concretions. It is gray, mottled gray, light yellowish gray, or dull grayish brown. Its depth varies from 50 to 80 cm. The substratum is of tuffaceous material.

Novaliches. The soils of this series occur on rolling and hilly topography while Prensa is on slightly rolling topography. The surface soil is light reddish brown, reddish brown to bright reddish brown. It is friable and granular; concretions are present; depth ranges from 20 to 40 cm. The subsoil towards the depth of 80 cm. is also friable and granular; concretions are intense. Towards the lower depth the color becomes bright reddish brown to brownish red or brick-red. Like Prensa, the substratum is of tuffaceous material.

Buenavista. The soils of this series are similar to Novaliches. "The peculiarity of this series is the presence in the subsoil of almost impervious light gray to light yellowish gray clay and concretions." The depth of the surface soil ranges from 20 to 40 cm. and the subsoil reaches the depth of 100 cm. from the surface.

Sibul. The relief is rough and hilly. The Sibul soils are derived from the weathering of calcareous rock material. The soil is fertile and supports a luxuriant growth of vegetation. The surface soil is dark brown to light grayish brown; depth 25 to 30 cm.; granular when dry. The subsoil varies from 45 to 70 cm. from the surface. It is coarse, granular and friable. Its color is dull brown to dull grayish brown.

Rizal Province

Soil series Obando, Quingua, Prensa, and Novaliches are described under Bulacan Province; and Bay series, under Maquiling area.

Rizal. This series is also known as hydrosol series. The area in which these soils are situated is utilized as fishponds or saltbeds.

The soils are, therefore, for the most part of the year submerged in water.

Guadalupe. The soils of this series are similar to Prensa and Novaliches as far as their parent material is concerned, but their profile characteristics differ considerably, both in color and consistency. Guadalupe soils also bear some similarities to Lipa and Ibaan soils of the Batangas and Maquiling areas in their origin and relief of the land. They, however, differ in the characteristics of their profile.

Profile—surface soil depth ranges from 20 to 30 cm.; dark to nearly black in color; coarse granular to cloddy when dry and very sticky when wet.
Subsoil—depth ranges from 40 to 80 cm. from the surface; color lighter than surface soil; finely granular when dry and sticky when wet.
Tuffaceous concretions with occasional limestone concretions are found in both surface and subsoil.

Topography—level in the lowland to slightly rolling in the upland.

Origin—soil is residual from the decomposition of volcanic tuff.

Mariquina. The soils of this series are alluvial deposits. They are located in the Mariquina valley from Montalban to Pateros. The chief river that goes through the valley is Mariquina River.

Profile—surface soil 20 to 25 cm. deep; light brown to brown in color; generally light in texture, friable, loose, granular.
Subsoil—very dark brown to dark gray horizon follows the surface soil; upper subsoil brown to dark brown in color, lower subsoil dark gray.
Substratum—underlaid by a bed of tuffaceous material.
Topography—generally flat. Drainage—good.

Binangonan. The soils of this series, like the Malabo soils of the Batangas area, are sedentary from limestone. Only one type was delineated, Binangonan clay. Both Binangonan clay and Malabo waxy clay possess dark-colored surface soil and are found in rough mountainous regions. They differ in the consistency of the soils; Malabo has waxy surface and subsoil.

Profile—surface soil depth 20 to 25 cm.; dark brown to nearly black; when dry soil is coarse granular to cloddy and when wet sticky.
Subsoil—depth extends to about 1 meter; lighter in color than surface soil; lower subsoil about 40 to 55 cm. from the surface is a calcareous horizon. Towards the lower depth soil consists of highly weathered limestone.
Substratum—stratified calcareous rock.

Antipolo. A large area of land characterized by red or reddish brown soils is found around the town of Antipolo. The soils are residual from the decomposition and disintigration of volcanic tuff, igneous and other volcanic rocks.

Profile—surface soil depth 25 to 30 cm.; light reddish brown to dark reddish brown; friable and granular; when wet, slightly sticky.
Subsoil—up to the depth of 50 to 60 cm. from the surface, soil is dark reddish brown; highly weathered tuffaceous materials are found. Towards the lower subsoil about 85 cm. from the surface, soil consists of highly weathered tuffaceous materials; lower part of subsoil is lined with weathered igneous or other volcanic rocks.

Topography—rolling, rough and mountainous in some regions. In some parts of the area basaltic boulders are exposed on the surface.

Drainage—good because of the rolling relief of the land.

SUMMARY

At present there are thirty-six soil series established: seven (Batangas area, 1903) by Dorsey, eleven (Silay-Saravia and La Carlota area, 1927 and 1931) by Pendleton, two (Bokakeng forest management project, 1932) by Pendleton and Aquino, one (Maquiling area, 1934) by Barrera and student theses, and fifteen (Bulacan and Rizal provinces, 1936 and 1937) by the Department of Agriculture and Commerce.

The descriptions of these series are scattered in several publications. It is highly desirable that they should be put together in one paper in order to serve as a convenient reference to pedologists engaged in soil survey in the Philippines. Unnecessary duplications in giving new series names may likewise be avoided.

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A REVIEW: "A NOTE-BOOK OF TROPICAL AGRICULTURE" [1, 2]

This "note-book" is a handy, pocket-size book in which were "put together some facts and figures concerned with tropical agriculture." The compilation of these data, which, according to the author, were gathered from many sources, must have consumed time. It is, however, time that was well spent, for the book is one that will be found useful by those interested in agriculture, particularly those engaged in tropical farming.

The data contained in the book include tables of equivalents of weights and measures and conversion factors from one unit of either weight or measure into another; aids in surveying and construction of buildings and roads; information on machinery; amount of labor needed in the preparation of land for planting, harvesting, and other farm chores; information on soils and manures and manuring; guides in planting tropical crops, including estimates on yield; and information on the different classes of live stock and the feeds and feeding of these. The various "recipes" of insecticides, fungicides, weed killers, grafting wax, and other things that are listed will be of interest to agriculturists.

Blank pages are inserted here and there throughout the book. This is another feature that may help in making the book of practical value to the farmer. More recent data or other pertinent information not found in the book may be added from time to time and thus keep the book up-to-date.

F. M. FRONDA
Of the Department of Animal Husbandry

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[1] WOOD, R. CECIL. 1937. A note-book of tropical agriculture. 146 p. Price, 5/3 post free (about ₱2.52). Trinidad (B. W. I.): The Imperial College of Tropical Agriculture.

[2] General contribution No. 578.

COLLEGE AND ALUMNI NOTES

The faculty, students, and employees of the College of Agriculture and the School of Forestry swelled by about 650 the big delegation from the Manila units of the University of the Philippines who made a pilgrimage to Calamba, Laguna province, on National Heroes' Day, November 30. A program was held and a marker set on the site of the former home of Dr. José Rizal.

The student honor roll released by the Secretary of the College contains the following names: Lorenzo P. Zialcita, senior; Ian Khambanonda, junior; and Remberto Z. Ver, senior.

Mr. Amando M. Dalisay, '37, has recently been appointed assistant instructor in poultry husbandry at this College. In addition to his regular duties, he is helping edit *The Philippine Agriculturist*.

Dr. Arturo B. Rotor succeeds Dr. Jaime Laico as College physician, after the latter's transfer to the Philippine General Hospital. Doctor Laico keeps his connection with the U. P. Los Baños Infirmary as visiting surgeon.

The program of the Los Baños Biological Club for November 18 included the following papers:

Dr. N. L. Galvez. Citric acid as a reagent in soil iron determination.
Dr. F. M. Fronda and Mr. Engracio Basio. The use of copra meal in duck rations for egg production.
Mr. V. M. Dawis. Variability among seedlings of *Anthurium crystallinum* Lind. et André.

Radio lectures were delivered by faculty members over station KZRM as follows:

Dr. José M. Capinpin, November 3, on crop improvement.
Mr. Florencio A. Soliven, November 10, on the rôle of microörganisms in the utilization of agricultural products.
Dr. Miguel Manresa, November 17, on the question of adaptability of local breeds of cattle to Philippine conditions.
Mrs. Harriett L. Richards, November 24, on provincialisms and some common errors in the use of English.

Recent visitors to the campus included Mr. Francisco D. Marquez, '15, chief of the agricultural extension division, Bureau of Plant Industry, accompanied by Mr. Antero Inciong, '27, of the same Bureau, October 30 to 31; Mr. Alfonso Villaflor, principal, Isabela High School, October 11; and Mr. Florencio [illegible] Ligon, '35, chemist of the Mt. Arayat Planters' Association.

The U. P. Rural High School's enrollment in the second semester, 1937-38, is 125.

According to recent advices, Mom Chao Chakrabandhu, '38, is at present employed in the soils section, Department of Agriculture and Fisheries, Siam, where he works under Dr. Robert L. Pendleton, formerly professor of soil technology at this College.

PATRONIZING HOME-MADE PRODUCTS [1]

It is reported that the National Economic Protectionism Association (NEPA) has increased its membership from 139 business firms in 1935 to 419 in 1936. The Association held 120 popular assemblies and meetings with an estimated attendance of 400,000 in 1936, compared with 83 meetings attended by about 100,000 in 1935. The work of the NEPA in 1936 has reached nation-wide proportions and the sales of home-made products have been increasing, as indicated by business transactions of the Manila Trading Center during the month of August, amounting to ₱5,976.89 in 1936, compared with ₱2,838.86 during the same period in 1935.[2] These figures are indeed encouraging, particularly on the part of those who have labored and are still laboring for this worthy cause.

The NEPA is engaged in the task of arousing popular interest in the products of home industries as a means of increasing the local demand for such commodities. This is advertising. Since most of the home-made products are not widely known, the NEPA's effort to educate the people as to their uses and as to the advantages of protecting the industries producing them is commendable and should be supported. There are, however, certain fundamental principles that should be considered, if the result of such a movement is to be permanent.

The philosophy back of the national economic protectionism movement is that, conditions being equal, there should be no excuse on the part of any Filipino for preferring imported goods to similar home-made products. In other words, other things being equal, any Filipino, if only for patriotic reasons, is under moral obligation to patronize the products of home industries.

But the above conditions, in most cases unfortunately, do not exist. One has only to try some of the native-woven cotton cloths to convince himself of the truth of this statement. The prints on such cloths fade after washing. Besides, they usually shrink on one side and elongate on the other. On the contrary, most of the imported cloths of similar material neither fade nor shrink. Naturally,

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[1] General contribution No. 606.

[2] See RAFAEL CORPUS. 1937. NEPA during the year 1936. The Philippine Journal of Commerce 13: No. 4, April, 1937.

when a person has had such an experience with native-woven cloths, he will not buy them again. He will be forced to buy the better imported goods. Again, a person may purchase a pair of home-made shoes, say of leather material, for six pesos. He will be able to use this pair of shoes only for two or three months. On the other hand, if he buys a pair of leather shoes imported into the country, say for twelve pesos, this will last him for at least one year. The person who uses his good judgment in spending will be forced to buy the imported shoes, which in the long run are more economical than the home-made article. Many other instances can be mentioned to illustrate the evident lack of effort to maintain quality in many of our native-made products to similar imported goods, but these are sufficient to emphasize the point. If such a condition is not corrected, no Filipino can be blamed for his preference for imported goods over home-made products. As a consumer, any Filipino, or any consumer for that matter, will use his income in buying things which give him the greatest satisfaction and service. President Manuel L. Quezon demonstrated his keen knowledge of the principles of marketing when he warned the National Economic Protectionism Association about a year ago that, so long as native-made products are not equal in quality to similar imported products, Filipino consumers will continue to prefer imported articles to products of home industries. To be productive of permanent results, President Quezon urged that native industries should strive to make the quality of their products at least equal to similar goods imported into the country.

The National Economic Protectionism Association can do something to encourage home industries to improve the quality of their products, thereby making effective and permanent the results of its advertising campaign. It can employ a method similar to that used by Great Britain in 1927-1928 to increase the consumption of British-made goods by British nationals at home and abroad. Realizing that British-made goods were meeting keener and keener competition at home and abroad from similar products produced elsewhere, the British government launched a vigorous advertising campaign inviting British nationals to buy British-made goods and protect British industries. It was thought, however, that a mere appeal to the nationalistic feelings of Britishers would not give permanent results. It was then decided that some sort of a guarantee of the quality of British-made goods be adopted. Thus British industries which joined the movement had to enter into a voluntary agreement with

the government to the effect that the British national trade mark will be stamped on all products of such industries which come up to standards set for each type of products. Goods below the standard will not bear the trade mark and will not be advertised. After this agreement was made, the vigorous advertising campaign was launched, both by the government and the newspapers. The British national economic protectionism movement, in other words, took the form of an appeal to British nationals at home and abroad to try British-made goods. And once they have done so, they were left to judge for themselves as to whether or not they must continue to use them and protect British industries. It might be mentioned, in passing, that Great Britain is not the only country which has employed its national trade mark to improve and guarantee the quality of the products of its industries. The practice was started by Denmark in 1900, and since that time it has been adopted by many other European countries, such as Australia, Canada, Hungary, Finland, and others.

Some such plan as the British method would make the work of the National Economic Protectionism Association more effective and its results permanent. Such a method, if adopted, would do away with the yearly campaign which has a tendency to make native industries rely more and more on the patriotic feelings and renewed enthusiasm of the inhabitants, which at least have only a temporary effect, rather than on the good will and "customers' choice" developed through the satisfaction and service which the consumers get out of the goods they buy.

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FACTORS RELATED TO INCOME AND COST OF PRODUCTION OF RICE ON TENANT HOLDINGS IN CABIAO, NUEVA ECIJA[1]

AMANDO M. DALISAY

WITH THREE TEXT FIGURES

Rice farming in the Philippines is largely on the basis of a partnership between a large landowner and share croppers, known locally as share tenants, or merely tenants. To understand the conditions of rice farming would, therefore, require a study of the conditions of share croppers. The rice tenant farmers' demands for social justice make a study of the actual situation on rice tenant holdings imperative.

A proper understanding of the tenant farmer's income is necessary to explain the deplorable conditions obtaining on the rice farms of this country. Not infrequently, the newspapers call attention to the poverty and want of tenant farmers and their families. Nueva Ecija, premier rice-growing province of the archipelago, is usually pointed out as a region of bountiful harvest and of plenty, but a place where the tenant farmer lives in a state devoid of the conveniences and comforts of decent farm living. As standard of living "depends to a very great extent on income," it can be inferred that our tenant farmers receive incomes insufficient to meet their needs. Before such a generalization can be accepted, it is necessary to know actual conditions attendant on rice tenant-farming.

Closely associated with the tenant's income is his cost of producing the rice crop. Recent efforts of the government have been directed toward regulation of rice prices to enable the farmer to derive sufficient income from his crop. If prices are lower than the farmer's costs of production, it may be deduced that it is not possible for the farmer to maintain an adequate standard of living.

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[1] Thesis presented for graduation, 1937, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 1075; Experiment Station contribution No. 1206. Prepared in the Department of Agricultural Economics under the direction of Assistant Professor José E. Velmonte and Assistant Instructor Marcelo V. Arnaldo.

The determination of the cost of producing rice per cavan or per hectare is, therefore, a necessary step in the determination of the equity of the returns on the labor and capital invested.

Velmonte and others (1934) pointed out that in an agricultural country like ours, it is of value to know whether or not the farmer receives adequate returns for his labor. The Philippine Economic Association (1934) in its study of rural problems called attention to the necessity of carrying on rural farming in such a way as to yield to the farmers at least a fair interest on their capital and an adequate income for a decent living. This latter study also stated, among other things, that even in times of good prices for rice, the tenant farmers and the small rice producers get hardly enough returns for their labors to meet the bare necessities of their homes and families. Velmonte (1934), commenting on some aspects of Philippine rural economy, stated that the average farm is far too small to support a decent standard of life for the farmer and his family; and that the income from the farm often has to be supplemented by incomes from secondary occupations to support even the barest mode of living.

According to Dixon and Hawthorne (1920), a farm cannot properly be called successful unless it pays a fair rate of interest on the investment, returns fair wages for the farmer's labor, and, at the same time, maintains or increases the fertility of the soil. Four important factors in the success of a farm business are pointed out, namely, (*a*) size of business, (*b*) yield of crops, (*c*) returns from livestock, and (*d*) efficiency in the use of labor. Studies on farm operation, organization, and management in the United States (Garman, 1932; Saville, 1933; Rouse, 1934) all pointed out several factors associated with income or with successful farm management, such as, size of business, crop yields, labor efficiency, intensity and diversity of production, and volume of sales.

Saville (1933), in his study of factors in the organization and successful operation of Louisiana rice farms, stated that the most common measure of success used in the analysis of farm business records is labor income. It has proved to be the most satisfactory measure of success since it provides a means of comparing widely different types and systems of farming on the basis of the financial returns to their operators. Garman (1932) used labor income as a

measure of financial success of farms in Marshall and de Kalb counties, Alabama, because farmers in the area studied were laborers more than they were capitalists, and because labor income enables comparison between farms with a large amount of family labor or large capital and those with a small amount of family labor or a small capital.

Hopkins and others (1932) pointed out that the chief reasons for making a study of the cost of producing crops are: (*a*) to discover the most improved methods of reducing the cost, and (*b*) to learn what crops give the most profitable returns. Catambay (1933) stated that the cost of production must be known in order to put the farming business on a sound basis, and, if possible, make it a profitable enterprise. Aragon (1932) emphasized the importance of studies on cost of production of any crop thus: (*a*) a thorough knowledge of cost of production will help the farmers to determine the price that should be placed on their products, and (*b*) this knowledge can be used as a basis in studying the ways by which they can make their farms pay more by reducing costs and increasing returns.

Very few studies on the cost of production of rice in the Philippines have been made. Sacay (1927) reported that in Nueva Ecija, the average cost of producing rice was ₱140.35 per hectare for the entire region; the average yield, 47.50 cavans per hectare; and the cost of production per cavan, ₱3.05. He also found that of the average cost, 38.39 per cent was for land use; 38.60 per cent, for man labor; 8.66 per cent, for animal labor; 7.71 per cent, for cost of threshing; 1.77 per cent, for seed; and 4.87 per cent, for other costs.

Aragon (1932), in his study of cost of producing lowland rice in the Philippines, reported that the cost of producing rough rice was ₱1.81 per cavan in the Central Luzon Agricultural School; ₱2.20, in Tarlac; ₱2.30, in Pangasinan; ₱2.42, in the College of Agriculture; and ₱2.95, in Nueva Ecija. The average for these different places was found to be ₱2.44 per cavan.

Catambay and Jugo (1933) studied the cost of production of lowland rice in the College of Agriculture and reported that the total cost of production per hectare was ₱104.43 or, at an average production of 61.22 cavans per hectare, a cost of production of ₱1.71 per cavan. Considering the land farmed by an owner, they found that this yields a net income of ₱18.01 per hectare.

The Philippine Journal of Commerce of April, 1936, estimated that the cost of production of rice grown under upland conditions is from ₱1.75 to ₱3.50 per cavan, considering the production per hectare to be from 20 to 40 cavans and total expenses to be ₱70.08 per hectare; of rice grown in lowland fields dependent upon rain, ₱2.14 to ₱3.57 per cavan, if production per hectare is from 30 to 50 cavans, and considering total expenses to be ₱107.23 per hectare; of rice grown in lowland farms with irrigation facilities, ₱2.19 to ₱3.29 per hectare, considering production per hectare to be 40 to 60 cavans and total expenses to be ₱131.75 per hectare.

The Rice Commission in its report to the President of the Philippines on March 6, 1936, mentioned, among other things, that in determining costs of production there should be taken into account conditions obtaining in different sections of the country and the cycle of good and bad harvests resulting from natural causes to enable the producer during times of abundant harvest to obtain compensation for losses during unfavorable years. The report took pains to show how handicapped a tenant farmer is who receives a share of 40 cavans from an average holding of 2½ hectares, or an income of ₱120 for one year (if palay sells for ₱3 a cavan), which if distributed over a year's period is equivalent to a daily wage of ₱0.33 for the family.

The objects of this study were (*a*) to determine the relation of some recognized factors to income on rice tenant holdings and (*b*) to determine the cost of producing rice per cavan in these tenant holdings.

This work covered the crop year 1935-36. The survey work started from the last week of May, 1935, continued during the semestral vacation and Christmas recess of the school year 1935-36, and terminated in the last week of May, 1936. Compilation of data was done in the College of Agriculture from October, 1936, to January, 1937.

The present work was conducted in the town of Cabiao, Nueva Ecija, on the Central Plain of Luzon.

This study covered 105 tenant farmers who are residents of the municipality of Cabiao, Nueva Ecija. The barrios of San Fernando, San Roque, Santa Rita, Sinipit, and San Vicente were particularly visited.

Several visits were made to each tenant farmer included in the survey. During the first visit at the start of the survey an inventory was taken of the tenant's farm property. During the following and subsequent visits, the farmer was asked about the progress of the work on the farm. During the summer vacation of 1936, a last visit was made to each tenant farmer, a final inventory of his farm property was taken, and the labor record finished; the receipts from supplementary enterprises and the rice harvest, together with the expenses incurred, were finally recorded. Questionnaires prepared in the Department of Agricultural Economics were used in the survey.

RESULTS AND DISCUSSION

Location and description of area studied

Cabiao is located in the southernmost part of the province of Nueva Ecija. It is one of the principal rice-growing towns of the province. It is crossed by the provincial road from Cabanatuan to Pampanga. The main tributary of the Pampanga River winds its way through the fields of the town. The dominant enterprise of the locality is rice farming. Other crops besides rice are corn, sugar cane, and tobacco. The rice farms are situated near the provincial road varying in distance from one kilometer to eight kilometers, or more. These farms, except for a few which are provided with their own private irrigation systems, are served by the Peñaranda River Irrigation System, a government irrigation project. Rice lands for the last three years sold at about ₱300 to ₱500 a hectare. Upland fields for corn, sugar cane, tobacco, and other minor crops sold for even much lower.

The town is accessible by bus transportation from Manila and from almost all towns of Nueva Ecija. The barrios of the town, except Sinipit and San Julian, are accessible by municipal roads through which the farmers transport their products on either *calesa* or bull carts. The barrios of San Fernando, San Roque, Santa Rita, and San Vicente are along the Cabanatuan-Arayat bus line of the Rural Transit Co.

According to the 1918 Census, the town of Cabiao had a population of 8,161. The total number of farms according to this census was 315, covering an area of 2,660 hectares, or an average of 8.44 hectares to a farm. From a comparison of the population with the

number of farms, 25 persons were found to every farm. Of the 315 farms, 231 or 73.3 per cent were irrigated and the rest, 84 or 26.7 per cent were not. Irrigated farms had an average area of 9.32 hectares; unirrigated, 6.02 hectares. Population estimates for 1935 show the population of Cabiao to be 8,025, or lower than that of the 1918 census.[2]

Farm labor is largely supplied out of the town's population. There are, however, labor migrants from the adjacent towns of San Isidro, San Antonio, Gapan, and Zaragoza, and from the provinces of

Photograph by M. V. Arnaldo

Fig. 1.—A typical home and family of a share tenant on a rice *hacienda* in Nueva Ecija

Pampanga and Bulacan during the peaks of transplanting and harvesting periods when demand for labor is greatest.

Conditions during period of study

Data on weather conditions for the locality, except rainfall, are not available. Figures on rainfall collected by the Nueva Ecija Sugar Mills, Inc., the lone sugar central of the town and the province, are as follows:

[2] GUIDOTE, JOSÉ. 1935. Estimated population of the Philippine Islands by provinces and municipalities as of July 1, 1935. The Philippine Statistical Review 2: 112–124.

Rainfall observations
Nueva Ecija Sugar Mills, Inc., Cabiao, Nueva Ecija

MONTHS	1930	1931	1932	1933	1934	1935
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
January	0.5	17.8	2.0	3.0	11.0	—
February	0.3	2.5	0.5	—	5.0	17.8
March	90.5	35.6	25.5	101.6	174.2	12.5
April	5.9	20.1	5.1	43.5	20.1	127.3
May	334.0	241.1	170.1	225.5	159.5	317.1
June	156.3	172.8	258.7	305.5	61.0	158.7
July	562.0	123.4	343.5	371.2	255.3	504.1
August	292.7	666.8	206.3	192.9	327.5	466.8
September	251.3	77.7	345.6	148.0	364.1	398.7
October	55.9	228.6	181.9	105.5	287.3	228.6
November	22.4	134.7	103.1	76.9	300.9	91.1
December	84.8	37.9	28.2	11.2	37.8	12.7
Average	154.7	146.6	139.2	132.1	167.0	194.6

August 3 and 4, 1935—Heavy rain and flood (1½ meters deep)
September 15 and 16, 1935—Heavy rain and flood (preceded by strong wind and rain)
October 4, 1935—Storm
November 16–18, 1935—Storm

Prices of products received by farmers were gathered from answers to questions asked by the writer during the period of the survey. On the average, farmers received ₱1.60 per cavan of palay at the beginning of the crop year (April, 1935) and about ₱3.00 per cavan [3] at the close of the crop year (March to April, 1936) or soon after harvest. While prices of palay under normal conditions are relatively lower soon after harvest than those during the middle of the year, in this particular instance prices in the early part of 1936 were rather high. This was because of the shortage in the rice crop, which resulted in heavy rice importation. Farmers received at the same time about ₱5.00 for every 1,000 ears of husked corn; ₱8.00 per *banig* (about 40 kgm.) of tobacco; and about ₱7.50 per picul of sugar.

Current wages in the locality are variable. Wages for transplanting rice seedlings vary from 40 to 60 centavos a day for individual transplanters. In harvesting rice, wages vary from 40 to 60 centavos per 100 square meters (one *luang*, Tag.) of palay cut or harvested. The current wage of laborers working in the sugar cane fields of the Cabiao Central (Nueva Ecija Sugar Mills, Inc.) is ₱0.60

[3] The Bureau of Commerce weekly market reports from January to May, 1936, give Cabanatuan palay quotations as ranging from ₱2.75 to ₱3.30 per sack (44 kilos) of Ordinario (ordinary, or Macan).

for a 10-hour day. If the laborer furnished his own carabao and plow, the daily wage is ₱1.50. These wages computed on the hour basis mean rates of 6 centavos per hour for man labor and 9 centavos per hour for animal and equipment use. These wage rates are used in evaluating labor cost in this study.

Charges for transplanting by informal organized units of transplanters, usually managed or headed by a *cabecilla,* range from ₱7.00 to ₱8.00 per cavan seed. Threshing charges, or the amount charged by owners of rice threshers (generally McCormick-Deering or Case grain threshers), vary from 3.84 to 5.00 per cent [4] of the amount of palay threshed. In only very few cases is threshing done by man or animal labor.

Rural credit in the locality is typical of that found in any rice-farming region in the province of Nueva Ecija. The tenant farmer borrows palay or cash from the landowner under terms, generally not included in the written tenancy contract. During the period of the present work, all palay advances made to the tenant by the landowner bear interest ranging from 4 cavans for every 10 cavans borrowed (40 per cent) to 1/2 cavan for every cavan borrowed (*talindua*) (50 per cent). *Talindua* generally prevailed in the locality. Cash loans are returned in kind after harvest on the basis of ₱1.20 to ₱1.50 per cavan. There are also cases in which cash loans for operating expenses are paid in palay on the basis of the current price at the time of settlement minus a deduction of 25 to 30 centavos per cavan.[5] The tenant farmer obtains credit from the landlord and money-lenders without any security. Palay or cash loans which are in almost all cases obtained at very high rates of interest are generally returned after threshing the rice crop. Interest on loans is computed without taking into consideration the time between the date of borrowing and the date of settlement. Besides the loans mentioned, the tenant farmer also obtains credit in the form of goods or farm implements from local stores for which payment is made in kind (palay) or money after harvest.

Landowners in turn obtain credit from Chinese rice millers of the town and of Gapan, a neighboring municipality. Loans are also

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[4] Threshing charges range from 4 cavans for every 104 cavans palay threshed (*sa labas*), or 3.84 per cent, to 5 cavans for every 100 cavans threshed (*sa loob*), or 5.0 per cent.

[5] For a more detailed explanation of terms on advances, *see* DALISAY, AMANDO M. 1937. Types of tenancy contracts on rice farms of Nueva Ecija. The Philippine Agriculturist **26**: 159–198.

obtained from the branch of the Philippine National Bank in Cabanatuan, Nueva Ecija.

Results of study

Farm investment. The average farm investment of a rice tenant farmer was ₱280.27 (table 1). Principal items of the tenant's farm investment were work animals, buildings, and tools and implements. Farm produce and supplies and livestock other than work animals were very minor investments. The average investment of a tenant farmer in work animals was ₱100.31; in buildings, ₱97.23; in tools and implements, ₱68.90; in farm produce and supplies, ₱16.50; and in livestock other than work animals, ₱5.79. A tenant farmer had, on the average, two work animals (carabaos) to work his holding.

The average inventory values for the year were used and the increase or decrease in inventory value was considered. Total net investment was obtained by considering accounts receivable and by deducting the value of accounts payable at the end of the crop year. In evaluating the investment items, current prices in the locality and ready-sale value at the time of inventory were used.

Farm receipts. The tenant's average farm receipts were ₱472.54 (table 4). This consisted of total receipts from rice, which amounted to ₱461.18, and from increase in inventory value, which was about ₱11.36. Total receipts from rice was computed on the basis of the average yield per tenant, 153.71 cavans of palay (44 kilos to a cavan), multiplied by the average price per cavan, ₱3.00, at the end of the crop year, or about the period of debt settlement in March to April. Increase in inventory was due mainly to increase in value of work animals and livestock by purchase or by birth.

Farm expenses. The tenant farmer's total farm expenses for the rice crop amounted to ₱371.22 (table 4). This included, in the present study, the interest on average farm investment, besides actual expenses for the rice crop. The interest rate used was 7 per cent, the rate charged by the Philippine National Bank on well-secured farm loans.

Labor income. Table 4 shows that the average labor income was ₱101.32 to a tenant holding. Labor incomes on the different tenant holdings covered by the survey ranged, however, from —₱1.25 to ₱402.22.

Factors related to income. In the present study the relation of (1) average farm investment, (2) size of tenant holding, and (3) rice yield to labor income have been determined.

(1) *Average farm investment.* Table 6 shows the relation between average investment and labor income. It may be noted that average farm investment bears no marked relation to labor income. While it is seen that 24 tenant holdings, or 22.86 per cent of all holdings, having average farm investment ranging from ₱100 to less than ₱200, had an average labor income of ₱114.08, 29, or 27.62 per cent of all holdings with greater average investment, ranging from

Photograph by M. V. Arnaldo

Fig. 2.—Employees' homes in a well-managed hacienda engaged in diversified farming in Nueva Ecija

₱200 to less than ₱300, had a lower labor income, ₱108.27. There was, however, a perceptible increase of labor income with increase in investment from ₱200 to ₱500 pesos, but an abrupt decrease after the ₱500 level was reached. Rouse (1934) stated that the size of business is usually an important factor in determining the net income of a farm operator. One measure of size of business is farm investment. The absence of a marked relationship between average farm investment and labor income does not invalidate the normal expectation of greater labor income with increasing investment; this merely implies greater emphasis that tenants may have possibly placed on

buildings and work animals which are the primary investment items and which do not necessarily affect directly the production of the rice crop. Furthermore, there is a limit of economy in size of farm investment in relation to farm area so that the abrupt decline in labor income after the ₱500 average investment was reached might have been due to over-capitalization.

(2) *Size of tenant holding.* The size of the farm is one of the important measures of the size of a farm business.

The size of tenant holding in this study averaged 3.4 hectares (table 1) and ranged from 0.62 to 7.5 hectares. In table 7 may be noted the relation of size of tenant holding to tenant's labor income. There is shown a very marked increase of labor income with increase in the size of holding. The average labor income increased steadily from ₱35.91 on tenant holdings under 2 hectares, or an average area of 1.17 hectares, to ₱174.87 on holdings with an area of 5 hectares and over, or an average of 5.48 hectares. The greatest number of tenants, 40, or 38.10 per cent of all those included in the study, had farms ranging from 3 to less than 4 hectares, or an average of 3.25 hectares, with an average labor income of ₱86.66 per tenant.

In connection with size of tenant holding, it should be noted that the tenant farmer had, besides his rice field, a small patch of corn, tobacco, or watermelon. It has been found that the area under either one of these secondary crops was so insignificant, usually 1/5 to 1/2 hectare, that they could hardly affect the total size of rice tenant holding as a factor related to income. It was found that, of 105 tenants included in this study, 23 had corn plots from which they derived gross incomes ranging from ₱16.00 to ₱68.00, or an average gross income for all tenants of ₱2.49; 19 tenant farmers tilled sugar cane fields that yielded them gross incomes ranging from ₱1.35 to ₱63.60, or an average of ₱4.97 for all tenants in the survey; and 2 farmers had watermelon patches which gave gross incomes from ₱60.00 to ₱90.00, or an average for all tenant farmers of ₱1.43. Although these minor enterprises yield only very small supplementary incomes, they could, if pursued with interest and industry, help a great deal in maintaining the tenant's family living.

(3) *Rice yield.* Table 3 gives the average yield of palay per tenant holding and per hectare. The average yield was 153.71 cavans to a tenant holding averaging 3.40 hectares, or an average production of 45.21 cavans to the hectare. Undoubtedly, the average rice yield would have been higher had it not been for the successive ravages of flood and storm on the crop during the year. Weather

observations of the Cabiao Central during the period of study show heavy rain and flood about 1½ meters deep on August 3 and 4, 1935; heavy rain and flood, preceded by strong wind and rain, on September 15 and 16; and storms on October 4 and on November 16 to 18, 1935.

It may be noted in table 8 that there was a very close relation between rice yield and labor income. There was a steady increase of average labor income from ₱5.31 on tenant holdings yielding less than 100 cavans palay, or an average of 60.37 cavans per holding or 25.57 cavans a hectare, to ₱305.26 on holdings yielding 300 cavans and over, or an average of 321.67 cavans per holding or 55.14 cavans

Photograph by M. V. Arnaldo

Fig. 3.—A swine project of a large estate owner in Nueva Ecija

a hectare. Thus labor income increased with increase in crop yield on tenant holdings. It should be noted, however, that 38 tenants, or 36.19 per cent of all tenants, representing the largest single group, came under yields from 100 to less than 150 cavans, or an average yield of 43.97 cavans per hectare. This group had an average labor income of ₱58.71 per tenant.

Supplementary income. The average supplementary income of a tenant farmer was ₱66.81 (table 4). On the whole this appears to be a significant item when it is considered that this value is more than one-half of the tenant's average labor income from the rice

crop. While it has been said elsewhere that supplementary income from minor crops was relatively small, earnings from miscellaneous sources, representing work outside the tenant's farm, enable him to derive a relatively larger amount of additional income. Theoretically, the labor income from the rice crop goes to the tenant as a reward or payment for his labor and management for the year; actually, however, very little of this amount remains with him, if any at all, because of the necessary payments he must make on the advances at very high rates made to him by his landowner or any local money-lender for his expenditures and those of his family.

The supplementary income enables the tenant farmer to tide over periods of scarcity and of want during the crop year and helps him to maintain his family living on a subsistence level. It is sad to note, however, that, on the whole, tenant farmers have not given the necessary attention to sources of supplementary income. Out of 105 tenant farmers in the survey, 90 raised chickens; 93, swine; only 8, ducks; 4, tobacco; 19, sugar cane, and only 2 had watermelon patches; and only a little more than one-third of the number of tenants received incomes from miscellaneous sources such as earnings in transplanting and harvesting, carpentry and calesa, labor in the sugar cane field, and other occupations. Earnings by members of the tenant's family were considered as tenant's supplementary income.

Length of tenure. Length of tenure is taken here to mean the total number of years an operator has spent as a tenant. According to Boñgato (1934) and Aala (1935), a greater proportion of the tenancies surveyed by them were worked by tenants who had occupied these holdings for about 5 years, taking length of tenure to denote length of stay on tenant holdings.

Table 5 shows that the average length of tenure for all tenant farmers included in this study was 18.17 years. The length of tenure for the different tenants varied, however, from 1 to 48 years. It should be noted, on the other hand, in connection with length of tenure that the tenant's stay on his present holding averaged 11.10 years and ranged from 1 to 36 years. All these seem to confirm the contention that in this country tenancy has a permanent status.

It is of interest to know the true relation between age of tenant farmer and length of tenure. It may be seen in table 5 that the ages of all tenants included in this study averaged 38.84 years and ranged from 18 to 69 years. Hester, Mabbun, and others (1924) found in their survey of 830 tenancies scattered over the provinces

of Bulacan, Cagayan, Pangasinan, Cavite, Laguna, and Iloilo that the average age of the tenant was 41 years. Table 9 shows the relationship of age of tenant farmer to length of tenure. Of the 105 tenants, 2, or 1.90 per cent, were under 20 years of age, with a corresponding average length of tenure of 2 years; 29, or 27.62 per cent, from 20 to less than 30 years, with a corresponding average length of tenure of 7.52 years; 29, or 21.62 per cent, from 30 to less than 40 years, with an average length of tenure of 13.69 years; 20, or 19.05 per cent, from 40 to less than 50 years, with an average length of tenure of 24 years; and 25, or 23.81 per cent, from 50 years and over, with an average length of tenure of 32.36 years. There was a very close relationship, as the length of tenure increased with increase in age of tenants; that is, the older the tenant farmer, the longer was his tenure as a tenant. This, of course, is to be expected. The facts, however, prove further the permanent nature of tenancy in the Philippines.

In connection with length of tenure, it may be of interest to know whether a relationship existed between size of holding and length of tenure. Table 10 shows that there was apparently a relationship, the size of tenant holding increasing with length of tenure among the different tenant farmers covered by the survey. This may be explained by the fact that as the tenant grows in experience he becomes more efficient and is thus enabled to farm a larger area. It should be noted, in this connection, that the greater proportion of the tenant farmers had an average length of tenure of 14.65 years, with the size of holdings ranging from 3 to less than 4 hectares, or an average of 3.25 hectares.

Tenant's helpers. Table 5 shows the number of tenants in this study with and without helpers. It may be seen that a tenant farmer has, on the average, about 2 helpers, one male and one female. The number of helpers to a tenant ranged, however, from none to 7, the number of male helpers varying from none to 5 and that of female helpers, none to 4. The average age of male helpers ranged from 19.15 to 23.85 years and that of female helpers, from 22.06 to 27.24 years.

Of all the tenants included in the study, 84 had helpers and 21 did not. Of those with helpers, 15 tenants had male helpers, usually their fathers; 24 tenants had female helpers, generally wives or sisters; and 45 had both male and female helpers, who in the majority of cases were brothers and sisters.

Cost of production of rice. Students of cost of production differ in their consideration of the elements of cost. Sacay (1927) considered the costs of man labor, animal labor, seed and threshing, land, and other items, including use of buildings, use of equipment, interest on operating expenses, and water charges. Aragon (1932) grouped the elements of cost into four; namely, (a) land, (b) man and animal labor, (c) implement, and (d) seed and miscellaneous. In a study of cost of production of lowland rice in the College of Agriculture, Catambay and Jugo (1933) used labor, supplies and land, and implement cost in arriving at the unit cost of production. In the present study it was deemed necessary to itemize costs into seed and fertilizer, irrigation, threshing, land use, man labor, animal labor, interest on cash loans for the rice crop, interest on average investment, and decrease in inventory.

(1) *Methods of arriving at the different elements of cost.* Seed and fertilizer cost was determined by evaluating the amount of each item actually used; that of seed was the actual amount planted for seed. This is deducted from the total harvest multiplied by the average price per cavan of palay after the harvesting season, namely, ₱3.00. Fertilizer which was used only for seedbeds during the period of the study was valued at ₱0.08 per kilogram. Irrigation expense is shared equally between the tenant and the landowner. Irrigation cost was determined by the contracted share rent value. If the landowner advanced the charge for irrigation, ₱11.85 for 3 hectares of rice land, or ₱3.95 per hectare, the amount of palay which was deducted from the total harvest on the basis of 1 cavan palay for every ₱1.50 advanced, 7.9 cavans, was considered as irrigation cost. This was valued at the current price after harvesting, ₱3.00 per cavan.

Threshing cost was determined on the basis of actual threshing charges (3.84 to 5.00 per cent of palay threshed) evaluated in a similar manner as above. Threshing charge is generally shared equally between the landowner and the tenant and is, therefore, deducted from the total harvest.

Land cost was determined by the value (at ₱3.00 per cavan) of the landowner's share of the net product, which is in all cases one-half. The net product is generally obtained by deducting from the total palay harvest the seed, irrigation and threshing charges, and the amount corresponding to the landowner's cash advances for the operating expenses plus their interest, which are all shared half-and-half.

Man labor cost was determined by totalling actual expenses and evaluating tenant's own labor at 6 centavos per hour. In the case of animal labor cost, animal labor hours were evaluated at ₱0.09 per hour, the local rate.

Interest on cash advances for the rice crop was determined by evaluating the increase over actual expenses in transplanting and harvesting when these are paid back in kind (palay) after harvest on the basis of the terms of the written tenancy contract. For example, a ₱21– advance for transplanting was paid in kind on the basis of 1 cavan for every ₱1.50 advanced. This would mean 14 cavans returned after harvest, or, at current prices after harvesting, an increase of ₱21.00 over actual expenses, which shows an interest of 100 per cent.

Interest on average farm investment was charged at 7 per cent, the Philippine National Bank rate on farm mortgages in the locality.

Decrease in inventory was obtained from the inventory. This included depreciation on buildings and on tools and implements, and breakage or loss by fire or accident.

(2) *Labor requirements of the rice crop.* Table 2 shows that total man labor requirement per tenant holding was 1,582.11 hours, or an average of 465.32 man hours per hectare. Animal labor hours totalled 498.74 per tenant holding, or an average of 146.68 per hectare. The table further shows that labor requirement was highest for harvesting, a total of 489.09 man labor hours per tenant holding, or 143.85 man hours per hectare; this was followed by transplanting, which required 360.62 man labor hours per tenant holding, or 106.07 hours per hectare; and third highest was plowing which required 181.67 man hours per tenant holding, or an average of 53.43 man hours per hectare. Animal labor requirement was highest for plowing, which used 181.67 animal hours per tenant holding, or 53.43 animal hours per hectare; second highest was for harrowing and reharrowing, 136.54 animal labor hours per tenant holding, or 40.16 animal hours per hectare; and third highest was for piling harvested palay, 105.45 animal hours per tenant holding, or 31.01 animal hours per hectare.

(3) *Cost of production per cavan and per hectare.* Table 3 shows the cost of production of rice per cavan and per hectare. It may be noted that the total cost of producing rice averaged ₱423.63 per tenant holding. Since the average area of a tenant holding was 3.40 hectares, the figure represents a cost of production of ₱124.59

per hectare. With the average production per hectare of 45.21 cavans, this would give a cost of production per cavan of ₱2.76.

Table 3 shows that the average total cost of production per hectare of ₱124.59 is distributed as follows: 2.17 per cent for seed and fertilizer; 3.72 per cent, irrigation; 5.42 per cent, threshing; 45.61 per cent, land; 8.93 per cent, hired labor; 12.37 per cent, tenant's own labor; 8.69 per cent, animal labor; 3.76 per cent, interest on cash loans; 4.63 per cent, interest on average investment, and 4.70 per cent, decrease in inventory. Summarized, the total cost of production per hectare consisted of 45.61 per cent for land, 29.99 per cent for man and animal labor, 13.09 per cent for interest and depreciation, and 11.30 per cent for seed, fertilizer, irrigation, and threshing.

Comparison of yield, cost, and labor requirements per hectare of lowland rice in this study with those of other studies. From the above discussion, it may be seen that the results of the present study show the following:

Average area of tenant holding—3.40 ha.
Average yield per hectare—45.21 cavans
Average cost of production per hectare—₱124.59
Average cost of production per cavan—₱2.76
Average labor requirements per hectare (hours):

	Man	*Animal*
Total hours	465.32	146.68
Preparation of seedbed and sowing	8.98	7.54
Land preparation	93.59	93.59
Transplanting (including preparation and distribution of seedlings)	137.34	4.66
Irrigation and weeding	34.44	—
Harvesting, piling, threshing, and hauling	190.97	40.89

(*1*) *Sacay's study of cost of production in 1926-27.* Sacay (1927), in his study of cost of production of lowland rice, 1926-27, reported the following average results for the province of Nueva Ecija:

Average area of farm —1.90 hectares
Average yield per hectare—47.50 cavans
Average cost of production per hectare—₱140.35
Average cost of production per cavan—₱3.05
Average labor requirements per hectare (hours):

	Man	*Animal*
Total hours [a]	410.56	136.56
Preparation of seedbed and sowing	13.76	13.76

[a] Computed from number of days at 8 hours a day

Land preparation	97.92	97.92
Transplanting	125.28	—
Harvesting, threshing, sharing, and hauling	173.60	24.88

Sacay (1927) pointed out that variation in cost per unit of product is influenced by the cost per hectare and yield; a much higher cost of production per hectare produces a low cost per cavan because of high yield.

(2) *Aragon's study of cost of production of lowland rice in the Philippines.* Aragon (1932) reported the following data as average figures for 1925-1929 on Central Luzon Agricultural School rice farms:

Average yield per hectare—90 cavans
Average cost of production per ha.—₱155.70
Average cost of production per cavan—₱1.81
Average labor requirements per hectare (hours):

	Man	*Animal*
Total hours	460	168
Preparation of seedbed and sowing	16	16
Land preparation	144	136
Transplanting	112	—
Harvesting, threshing, sharing, and hauling	188	16

Aragon (1932) found that of the five regions or places covered by the study (Tarlac, Pangasinan, Nueva Ecija, Central Luzon Agricultural School, and College of Agriculture), Nueva Ecija has the highest cost of production per unit of product, ₱2.95 per cavan. The average cost for all the five places was found to be ₱2.44 per cavan.

(3) *Catambay and Jugo's cost study in the College of Agriculture.* In studying the cost of production of lowland rice in the College of Agriculture, covering 31.0716 hectares, Catambay and Jugo (1933) found these figures:

Average yield per hectare—61.22 cavans
Average cost of production per hectare—₱104.43
Average cost of production per cavan—₱1.71
Average labor requirements per hectare (hours):

	Man	*Animal*
Total hours	522.24	188.03
Preparation of seedbed and sowing	16.41	10.94
Land preparation	204.14	175.37
Transplanting	63.29	1.72
Harvesting, threshing, and sharing	238.40	—

In the above figures for man labor hours in land preparation, time devoted to cleaning and repairing dikes was included; animal

labor hours in transplanting were used up in transporting bundled seedlings for transplanters.

From the figures cited above, it may be readily noted that the cost of production per cavan in the present study was much higher than that in the other investigations. It is generally admitted, however, that comparisons of cost of production are not usually possible because of the variability of cost even from the same area for different crop years. Nevertheless, there were obvious factors, which are worth mentioning, that accounted for the relatively high cost in this study. One of these was the relatively low yield of palay in the locality per tenant holding and, consequently, per hectare, owing mainly to the ravages of the storms and floods during the crop year. Another was the extraordinarily high price of palay at the close of the crop year, arising from the shortage in the rice crop throughout the country. The high prices of palay necessitated heavy importations from Saigon and government activities aimed at price regulation and control of rice distribution. Undoubtedly, the high prices of palay affected computation of costs and income. Finally, the very high rates of interest on cash advances for operating expenses, generally 100 per cent and over, should be taken into consideration in explaining the high cost of production per cavan of palay.

SUMMARY AND CONCLUSIONS

1. An attempt has been made to determine the income of tenant farmers on rice holdings and the possible influence which some recognized factors may bear on this income. Also the cost of producing rice on tenant holdings has been studied.

2. The present study covered 105 tenant farmers in the municipality of Cabiao, Nueva Ecija, on the Central Plain of Luzon.

3. The total area of tenant holdings included in this survey was 357.01 hectares, or an average of 3.40 hectares per tenant holding.

4. The average farm investment of a rice tenant farmer was ₱280.27. The average investment in work animals was ₱100.31; in buildings, ₱97.23; in tools and implements, ₱68.90; in farm produce and supplies, ₱16.50; and in livestock other than work animals, ₱5.79.

5. The tenant's farm receipts were, on the average, ₱472.54. This consisted of total receipts from rice, ₱461.18, and from increase in inventory value, ₱11.36.

6. The tenant farmer's farm expenses for the rice crop amounted to ₱371.22. This included interest on farm investment, besides the actual operating expenses for the rice crop.

7. The tenant's labor income was found in this study to be, on the average, ₱101.32. Labor incomes on the different tenant holdings covered by the survey ranged from —₱1.25 to ₱402.22. Three recognized factors were considered in relation to labor income; namely, (*a*) average farm investment, (*b*) size of tenant holding, and (*c*) rice yield.

8. Average farm investment was found to bear a fair relation to labor income; that is, up to a certain point, increase in investment yielded an increase in labor income, but beyond this point further increase in investment gave an abrupt decrease in labor income. With an average investment of from less than ₱100 to less than ₱500, or a range of from ₱58.93 to ₱442.96 per tenant holding, the average labor income increased from ₱58.26 to ₱133.09 per tenant holding. With an average investment of ₱500 and over, the average labor income fell down to ₱63.28 per tenant holding.

9. The size of the farm was found to bear a very marked relationship to average labor income. With increase in size of holding from less than 2 hectares to 5 hectares and over, or from an average size of 1.17 hectares to 5.48 hectares, the average labor income increased from ₱35.91 to ₱174.87 per tenant holding.

10. In connection with size of tenant holding, it was found to be directly related to length of tenure. The size of tenant holding increased with increase in length of tenure. A greater proportion of the tenants, 40 tenants, or 38.10 per cent of all those included in the survey, had an average length of tenure of 14.65 years per tenant, with an average size of holding of 3.25 hectares to a tenant.

11. Rice yield averaged for all farms 153.71 cavans per tenant holding, or an average production of 45.21 cavans per hectare. Rice yield was also found to be closely related to labor income; there was a steady increase of labor income from ₱5.31 to ₱305.26 with increase in yield from 60.37 to 321.67 cavans per tenant holding, or from 25.57 to 55.14 cavans per hectare.

12. The average supplementary income of a tenant farmer was about ₱66.81. This supplementary income enables the tenant farmer to tide over periods of scarcity and of want during the crop year and helps him to maintain his family. This is because, in actual practice, very little, if any, of the tenant's labor income remains with him after payment has been made on his borrowings plus interest.

13. Length of tenure for all farms surveyed averaged 18.17 years per tenant and ranged from 1 to 48 years. Average length of stay on present holdings averaged 11.10 years per tenant and ranged from 1 to 36 years.

14. It was found that a tenant farmer had, on the average, 2 helpers, one male and one female. Usually the helpers were his brother and his wife or sister.

15. The total man labor requirement per tenant holding was 1,582.11 hours, or an average of 465.32 man hours per hectare. Animal labor hours totalled 498.74 per tenant holding, or an average of 146.68 per hectare. Labor requirement was highest for harvesting, 489.09 man labor hours per tenant holding, or 143.85 man hours per hectare; second highest for transplanting, 360.62 man labor hours per tenant holding, or 106.07 hours per hectare; and third highest for plowing, 181.67 man hours per tenant holding, or an average of 53.43 man hours per hectare. Animal labor requirement was highest for plowing, second highest for harrowing and reharrowing, and third highest for piling harvested palay.

16. The total cost of producing lowland rice averaged ₱423.63 per tenant holding. Since the average area of tenant holdings was 3.40 hectares, this figure represents a cost of production of ₱124.59 per hectare. With the average production per hectare of 45.21 cavans, this gives a cost of production per cavan of ₱2.76.

17. The average total cost of production per hectare of ₱124.59 is distributed as follows: 2.17 per cent of the total cost consisted of seed and fertilizer; 3.72 per cent, irrigation; 5.42 per cent, threshing; 45.61 per cent, land; 8.93 per cent, hired labor; 12.37 per cent, tenant's own labor; 8.69 per cent, animal labor; 3.76 per cent, interest on cash loans or advances for the rice crop; 4.63 per cent, interest on average investment; and 4.70 per cent, decrease in inventory.

18. The cost of production of ₱2.76 per cavan in this study was much higher than that obtained in other investigations. There were obvious factors that accounted for this high cost; namely, the relatively low yields because of unfavorable weather conditions, the high price of rice due to an acute crop shortage, and the usual high rates on cash advances for operating expenses. Because of the variability of costs even for the same area for different crop years, a comparison of costs of production is not always possible and justifiable.

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TABLE 1

Farm investment of 105 tenant farmers

	FOR ALL FARMERS	AVERAGE VALUE [1]
	pesos	*pesos*
Average investment for the year	29,428.53	280.27
Buildings	10,209.00	97.23
Tools and implements	7,234.46	68.90
Work animals	10,532.60	100.31
Livestock	607.83	5.79
Farm produce and supplies	1,733.00	16.50
Accounts receivable	912.20	8.69
Total assets	31,229.09	297.42
Accounts payable	1,441.10	13.72
Total investment	29,787.89	283.70

[1] Computed for each tenant farmer

TABLE 2

Labor requirements per tenant holding and per hectare [2]

	MAN LABOR		ANIMAL LABOR	
	Per tenant holding	Per hectare	Per tenant holding	Per hectare
	hours	*hours*	*hours*	*hours*
Total	1582.11	465.32	498.74	146.68
Preparation of seedbed	28.10	8.26	25.65	7.54
Sowing seed	2.45	0.72	—	—
Plowing	181.67	53.43	181.67	53.43
Harrowing and reharrowing	136.54	40.16	136.54	40.16
Preparation of seedlings (including distribution)	106.33	31.27	15.85	4.66
Transplanting	360.62	106.07	—	—
Irrigating & weeding	117.10	34.44	—	—
Harvesting (including bundling)	489.09	143.85	—	—
Piling harvested palay	115.84	34.07	105.45	31.01
Threshing	10.79	3.17	—	—
Hauling	33.58	9.88	33.58	9.88

[2] Computed on the basis of 105 tenant holdings with a total area of 357.01 hectares, or an average area of 3.40 hectares per holding

TABLE 3

Cost of production of rice per cavan and per hectare [3]

ITEMS OF COST	AVERAGE COST PER TENANT HOLDING	AVERAGE COST PER HECTARE	PER CENT OF TOTAL
	pesos	*pesos*	
Seed and fertilizer	9.16	2.69	2.17
Irrigation	15.78	4.64	3.72
Threshing	22.95	6.75	5.42
Land use	193.21	56.83	45.61
Man labor cost			
Hired labor (708.65 hrs.)	37.84	11.13	8.93
Tenant's labor (873.46 hrs. at ₱0.06 an hr.)	52.41	15.41	12.37
Animal labor cost	36.82	10.83	8.69
Interest on cash loans for the rice crop	15.96	4.69	3.76
Interest on average investment at 7 per cent	19.62	5.77	4.63
Decrease in inventory	19.88	5.85	4.70
Total cost	423.63	124.59	100.00
Average yield in cavans	153.71	45.21	
Average cost per cavan (pesos)	2.76	2.76	

[3] On the basis of an average area of 3.40 hectares per tenant holding

TABLE 4

Labor income from rice and supplementary income of a tenant farmer [a]

Total Receipts		₱472.54
Total receipts from rice	₱461.18	
Increase in inventory value	11.36	
Total Expenses		371.22 [b]
Expenses for the rice crop	351.60	
Interest on average investment at 7%	19.62	
Labor income from rice		₱101.32
Supplementary income		
Chicken	6.79	
Swine	15.41	
Duck	0.49	
Corn	2.49	
Sugar cane	4.97	
Tobacco	1.20	
Watermelon	1.43	
Miscellaneous	34.03	
Total supplementary income		₱ 66.81

[a] Based on the average for 105 tenant farmers
[b] Not including value of tenant's own labor

TABLE 5

Age of tenant, length of tenure, number and age of helpers to tenants, and tenants with and without helpers

	FOR 105 TENANT FARMERS		RANGE
Average age of tenant	38.84 years		18 to 69 years
Average length of tenure (years as tenant)	18.17 years		1 to 48 years
Average length of stay on present holding	11.10 years		1 to 36 years
Average number of helpers	1.93		0 to 7 helpers to a tenant
Male helpers		0.96	0 to 5 helpers to a tenant
Female helpers		0.97	0 to 4 helpers to a tenant
Age of helpers [1]			
Male helpers			19.15 to 23.85 years
Female helpers			22.06 to 27.24 years
Tenants with helpers	84		
With male helpers		15	
With female helpers		24	
With both male and female		45	
Tenants without helpers	21		

[1] Average for each sex

TABLE 6

Relation of average investment to labor income

INVESTMENT	NUMBER OF TENANTS		AVERAGE INVESTMENT	AVERAGE LABOR INCOME
	number	*per cent*	*pesos*	*pesos*
For all tenant holdings	105	100.00	280.27	101.32
Under ₱100	15	14.28	58.93	58 26
₱100 to less than ₱200	24	22.86	146.71	114.08
₱200 to less than ₱300	29	27.62	245.04	108.27
₱300 to less than ₱400	11	10.48	349.26	112.25
₱400 to less than ₱500	15	14.28	442.96	133.09
₱500 and over	11	10.48	675.54	63.28

TABLE 7

Relation of size of tenant holding to labor income

SIZE OF TENANT HOLDING	NUMBER OF TENANTS		AVERAGE SIZE OF TENANT HOLDING	AVERAGE LABOR INCOME
	number	*per cent*	*ha.*	*pesos*
For all tenant holdings	105	100.00	3.40	101.32
Under 2 hectares	4	3.81	1.17	35.91
2 to less than 3 hectares	31	29.52	2.46	58.69
3 to less than 4 hectares	40	38.10	3.25	86.66
4 to less than 5 hectares	14	13.33	4.17	172.21
5 hectares and over	16	15.24	5.48	174.87

TABLE 8

Relation of rice yield to labor income

RICE YIELD	NUMBER OF TENANTS		AVERAGE RICE YIELD		AVERAGE LABOR INCOME PER HOLDING
			Per holding	Per hectare	
	number	*per cent*	*cavans*	*cavans*	*pesos*
For all tenant holdings	105	100.00	153.71	45.21	101.32
Under 100 cavans	18	17.14	60.37	25.57	5.31
100 to less than 150 cavans	38	36.19	126.61	43.97	58.71
150 to less than 200 cavans	24	22.86	169.02	47.31	124.20
200 to less than 250 cavans	16	15.24	228.03	50.18	173.72
250 to less than 300 cavans	6	5.71	268.74	54.20	272.59
300 cavans and over	3	2.86	321.67	55.14	305.26

TABLE 9

Relation of age of tenant farmer to length of tenure

AGE OF TENANT	NUMBER OF TENANTS		AVERAGE AGE OF TENANT	AVERAGE LENGTH OF TENURE
	number	*per cent*	*years*	*years*
For all tenant holdings	105	100.00	38.84	18.17
Under 20 years	2	1.90	18.5	2
20 to less than 30 years	29	27.62	25.41	7.52
30 to less than 40 years	29	27.62	34.72	13.69
40 to less than 50 years	20	19.05	44.05	24
50 years and over	25	23.81	56.64	32.36

TABLE 10

Relation of size of tenant holding to length of tenure

SIZE OF TENANT HOLDING	NUMBER OF TENANTS		AVERAGE SIZE OF HOLDING	AVERAGE LENGTH OF TENURE
	number	*per cent*	*ha.*	*years*
For all tenant holdings	105	100.00	3.40	18.17
Under 2 hectares	4	3.81	1.17	8.5
2 to less than 3 hectares	31	29.52	2.46	17.13
3 to less than 4 hectares	40	38.10	3.25	14.65
4 to less than 5 hectares	14	13.33	4.17	22.07
5 hectares and over	16	15.24	5.48	28.00

COMPARATIVE PERFORMANCE TESTS OF THREE NEWLY DEVELOPED C. A. C. VARIETIES OF SUGAR CANE [1]

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There are many new seedling varieties of sugar cane which have been produced and have passed yearly selections in the College of Agriculture. The most promising among these are treated in this paper. The results presented herein were obtained from three-year tests of College cane seedlings with some commercial varieties of sugar cane. The objects of these tests were (*a*) to compare some of the important agronomic characters of some College cane seedlings with commercial varieties of sugar cane and (*b*) to determine the comparative yields of cane and sugar and sugar per ton cane of these different varieties.

This study was carried out in the Experiment Station grounds of the College of Agriculture from January, 1934, to February, 1937.

MATERIALS AND METHODS

Fields used. The tests were conducted in two separate fields. The first field had an area of 0.9 hectare. The soil is clay loam. It was divided into 30 plots, 100 meters by 3 meters, or 300 sq. m. each. There were three rows in each plot; the rows were one meter apart. The 1934-1935 ratoon crop, which was a first ratoon, was harvested from this field.

The second field had an area of about 1.5 hectares. The soil is clay loam. The field was divided into several plots with areas ranging from 250 sq. m. to 500 sq. m. The 1935-36 plant crop and its first ratoon, or 1936-37 ratoon crop, were harvested from this field.

Varieties used. For the 1934-35 ratoon crop the following commercial varieties were used: POJ 2878, N. G. 24A, and M-1900. The College cane seedlings used were C. A. C. 117, C. A. C. 126, and C. A. C. 128. These College cane seedlings were produced under

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the direct supervision of Dr. N. B. Mendiola, by the plant breeding division of the Department of Agronomy. These were hybrids between P. B. 119 and C. A. C. 87.

For the 1935-36 plant crop and its first ratoon, or 1936-37 crop, the following varieties were used: N. G. 24A, POJ 2878, P. S. A. 14, P. S. A. 7, C. A. C. 117, C. A. C. 126, and C. A. C. 128.

Preparation of the land and planting. The land was prepared in the usual fashion. The furrows were made just before planting. They were set 100 centimeters apart. The seed pieces were planted 75 centimeters apart in the row, one seed piece to a hill.

Care of culture. In the plant crop the canes were cultivated as in the ordinary commercial method, which was an alternate hilling-up and off-barring. In the ratoon crops the trash was first burned immediately after harvesting and the field disced to cut all the protruding portions of the stubbles and old roots. Then alternate off-barring and hilling-up were done. Both the plant and ratoon crops were fertilized with ammonium sulfate at the rate of 350 kgm. per hectare.

Field observations. Periodic observations were made from the time of planting or ratooning until harvesting. The percentages of germination and stand and relative abundance of weeds were observed. At maturity lodging and percentages of dead and rat-infested canes were observed. Also the forage produced was weighed and recorded separately.

Harvesting and determination of yield. The canes were harvested at maturity. They were harvested, weighed, milled, and analyzed separately with the help of Dr. Getulio Guanzon, of the sugar technology division, Department of Agricultural Chemistry. The canes were milled in the U. P. Sugar Mill.

The crusher juice of the canes from each plot was analyzed and the degree Brix and percentage of polarization were recorded. From these data, the apparent purity, piculs sugar per ton cane, and piculs sugar per hectare of each variety were determined according to *Methods of Chemical Control for Cane Sugar Factories*, published by the Association of Hawaiian Sugar Technologists in 1931.

RESULTS AND DISCUSSION

The 1934-35 ratoon crop. The results of this study are presented in table 1 which shows the average yields of cane and sugar per hectare and piculs sugar per ton cane of the different varieties.

Comparative yield of cane. It will be seen in table 1 that C. A. C. 128 gave the highest yield of cane per hectare, 53.30 ± 3.40 tons; and M-1900, the lowest, with only 13.89 ± 0.41 tons. The differences in the yields of cane of POJ 2878, C. A. C. 117, C. A. C. 126, and C. A. C. 128 were insignificant. However, these four varieties gave a significantly higher yield of cane than either N. G. 24A or M-1900.

Comparative yield of sugar. It will be seen in table 1 that C. A. C. 128 gave the highest yield of sugar, 80.29 ± 2.26 piculs per hectare; and, with the exception of POJ 2878, C. A. C. 128 gave a significantly higher yield of sugar than any of the varieties tested. The differences in the yield of sugar of POJ 2878, N. G. 24A., C. A. C. 117, and C. A. C. 126 were insignificant. M-1900 gave significantly lower yield of sugar than any of the varieties tested.

Comparative yield of sugar per ton cane. The yield of sugar per ton cane of the different varieties ranged from 1.21 ± 0.02 to 1.75 ± 0.02 piculs, M-1900 having the highest and C. A. C. 126, the lowest. There was no significant difference in the yield of sugar per ton cane between the three standard varieties, POJ 2878, N. G. 24A, and M-1900. However, all of these standard varieties gave significantly higher yield of sugar per ton cane than any of the College seedling varieties. Likewise C. A. C. 117 and C. A. C. 128 gave significantly higher yield of sugar per ton cane than C. A. C. 126. There was no significant difference between the yield of sugar per ton cane of C. A. C. 117 and C. A. C. 128.

As a whole, the results show that in Los Baños POJ 2878 is the best standard variety, on the basis of its performance in the first ratoon. The other two standard varieties, M-1900 and N. G. 24A, were poor ratooners. The College seedling varieties C. A. C. 117, C. A. C. 126, and C. A. C. 128 compared favorably with POJ 2878 on the basis of yield of cane and sugar. However, they were inferior to POJ 2878 with respect to yield of sugar per ton cane. Of the three College seedlings C. A. C. 128 is the best as it gave the highest yields of canes and sugar per hectare, outyielding all of the varieties studied including the standard ones in this respect. Also, of all the College cane seedlings it had the highest purity of juice. C. A. C. 117 ranked second among the College seedlings, for, although it gave practically the same yield of cane and sugar as C. A. C. 126, it had a significantly higher purity of juice than C. A. C. 126. Among the College seedlings C. A. C. 126 is the poorest.

1935-36 plant crop. The results of this study are presented in tables 2 to 6.

Percentages of germination and stand. Table 2 shows the percentages of germination and stand of the different varieties of sugar cane studied. It will be seen in this table that P. S. A. 14 had the highest percentage of germination with 75.23 per cent, POJ 2878 ranked close second with 73.35 per cent. C. A. C. 117, C. A. C. 126, and C. A. C. 128 had each about 65 per cent germination; P. S. A. 7 and N. G. 24A had the lowest, each having about 60 per cent germination. The percentage of stand of the different varieties was in the same order as with germination.

Observations on external signs of arrowing and percentage of arrowing. All the varieties studied produced flowers with the exception of N. G. 24A and P. S. A. 14. The following four stages of arrowing were noted:

Boenting. At this stage, the highest leaf sheath begins to elongate and the leaf blade begins to shorten.

Flag stage. At the flag stage, the last leaf takes a slightly inclined to a vertical position.

Shooting stage. The shooting stage is observed at the moment the tip of the arrow begins to appear.

Opening stage. At the opening stage the stamens and pistils appear.

The different varieties exhibited these various stages at different times. On October 14, 1935, some of the POJ 2878 canes were at the boenting and shooting stages. On November 12, 1935, some of the stalks of C. A. C. 117 and C. A. C. 126 were at boenting and shooting stages. On this same date most of the stalks of C. A. C. 128 were at shooting stage. According to these observations the different varieties tasseled in the order of their earliness as follows: POJ 2878, C. A. C. 128, C. A. C. 117, C. A. C. 126, and P. S. A. 7.

Table 3 shows the percentage of tasseling of the different varieties of sugar cane studied. It will be seen in this table that, ranked according to average percentages of tasseling, the different varieties stood as follows: C. A. C. 128, 96.33; POJ 2878, 87.33; C. A. C. 117, 70.33; C. A. C. 126, 63.00 and P. S. A. 7, 46.66 per cent.

Percentage of dead and rat-infested stalks. Table 4 shows the percentage of dead and rat-infested stalks. Of the different varieties of sugar cane, C. A. C. 128 and N. G. 24A had the highest percentages of stalks eaten by rats. This may be due to the fact that these two varieties have soft rinds. Besides, N. G. 24A has a lodging habit and is easily affected by strong winds. None of the stalks

of P. S. A. 14 was attacked by rats and only one per cent of these of P. S. A. 7 were eaten by rats.

C. A. C. 128 had the highest percentage of dead stalks, 4 per cent. This may be due to the fact that this cane is brittle and suffered most from strong winds. Only a few of the stalks of the other varieties died and may not have a significant effect upon the yields of cane and sugar.

Comparative yield of cane. The comparative yields of cane and sugar and piculs sugar per ton cane of the different varieties are shown in table 5. The average yield of cane ranged from 55.21 $\pm$ 6.07 to 84.50 $\pm$ 0.49 tons per hectare. P. S. A. 7 gave the highest average yield of cane per hectare which was statistically significant compared with that of any variety included in the test. The differences in the yield of cane of the other varieties were statistically insignificant, with the exception of C. A. C. 117, which gave a higher yield of cane than C. A. C. 126, and the difference was significant.

Comparative yield of sugar. It will be seen in table 5 that the average yield of sugar per hectare ranged from 83.11 $\pm$ 7.98 to 163.42 $\pm$ 10.95 piculs. P. S. A. 7 gave the highest average yield of sugar per hectare, and with the exception of P. S. A. 14, it gave statistically significant more sugar per hectare than any other variety studied. P. S. A. 14 gave higher yield of sugar per hectare than C. A. C. 126 and C. A. C. 128 and the differences were statistically significant. The differences in the yield of sugar of P. S. A. 14 on one hand and that of the other varieties on the other were insignificant. C. A. C. 117 gave more sugar per hectare than C. A. C. 126 and the difference was significant. The differences in the yield of sugar of the other varieties were insignificant.

Comparative yield of sugar per ton cane. The average yield of sugar per ton cane ranged from 1.34 $\pm$ 0.09 to 2.15 $\pm$ 0.03 piculs. P. S. A. 14 gave the highest and C. A. C. 128, the lowest yield of sugar per ton cane. P. S. A. 14 gave significantly more sugar per ton cane than N. G. 24A, C. A. C. 117, C. A. C. 126, and C. A. C. 128. P. S. A. 7 gave more sugar per ton cane than C. A. C. 126, and C. A. C. 128, and the differences were significant. POJ 2878 gave slightly more sugar per ton cane than C. A. C. 128. The differences in the yield of sugar per ton cane of the other varieties were insignificant.

That low sucrose content is not necessarily a characteristic of C. A. C. 117 is proved by the fact that in Canton, China, as high as three piculs sugar per ton cane are obtained from this variety when

supplied with sufficient irrigation water, according to professor R. H. King, formerly sugar technologist, Canton Provincial Government.

That C. A. C. 128 had a rather poor sugar content in this test, with only 1.34 ± 0.09 piculs sugar per ton cane, may be due to the fact that most of the canes broke and died on account of the typhoons. This variety is brittle and soft; hence, it suffered most from the typhoons. Also the canes were badly attacked by rats.

As a whole, the results on the plant crop show that P. S. A. 7 was the highest yielder of cane and sugar per hectare. P. S. A. 14 had the best quality ratio. P. S. A. 7 and P. S. A. 14 were superior to the three College cane seedlings on the basis of sugar per hectare and sugar per ton cane. The three College cane seedlings compared favorably with two standard varieties, N. G. 24A and POJ 2878, on the basis of yields of cane and sugar per hectare.

Comparative yield of forage. The comparative yield of forage of the different varieties is shown in table 6. The average yield of forage ranged from 4.054 tons to 12.501 tons per hectare. N. G. 24A, a non-flowering variety, gave the highest yield of forage, with an average of 12.501 tons per hectare. POJ 2878 and C. A. C. 128, the two early and profusely flowering varieties of sugar cane, gave the lowest yield of forage, with an average each of about 4 tons per hectare. All the other varieties gave more than 5 tons of forage each per hectare.

Results of the ratoon crop, 1936-37

The results of this study are presented in table 7.

Comparative yield of cane. It will be seen in the table that C. A. C. 128 had the highest average yield, 64.19 ± 4.92 tons cane per hectare, and P. S. A. 7 was close second, 62.45 ± 2.76 tons. N. G. 24A had the lowest yield, only 14.70 ± 2.08 tons per hectare. The other varieties had each about 50 tons cane per hectare.

As a whole, the results show that N. G. 24A was the poorest ratooner as it had a significantly lower yield of cane than any of the varieties tested. The other varieties compared favorably on their yield of cane per hectare, as the differences were insignificant.

Comparative yield of sugar. The results show that P. S. A. 7 had the highest average yield of sugar, 104.60 ± 4.55 piculs per hectare, and N. G. 24A had the lowest, only 25.17 ± 3.16 piculs per hectare. P. S. A. 7 gave significantly higher yield of sugar than C. A. C. 126 and C. A. C. 128. Also P. S. A. 14 and C. A. C. 128 gave significantly higher yield of sugar than C. A. C. 126.

As a whole, these results show again that N. G. 24A was the poorest ratooner, as it gave the lowest yield of sugar. C. A. C. 126 was also a poor sugar yielder as it gave an average of only 64.41 ± 5.60 piculs sugar per hectare, while the rest gave a yield of from an average of 81.50 ± 7.48 to 104.60 ± 4.55 piculs per hectare.

Comparative yield of sugar per ton cane. It will be seen in the table that P. S. A. 14 had the highest yield of sugar per ton cane, with an average of 1.81 ± 0.08 piculs. P. S. A. 7, N. G. 24A, POJ 2878, and C. A. C. 117 had each more than 1.5 piculs sugar per ton cane. However, C. A. C. 126 and C. A. C. 128 had each less than 1.4 piculs sugar per ton cane. The poor sugar content of C. A. C. 128 may be due to the fact that it was greatly affected by the typhoon, as this variety is brittle. Most of the canes broke or lodged down. The lodging canes were in turn attacked by rats, as it was found out that this variety had the highest percentage of stalks eaten by rats, with 17 per cent. Undoubtedly, the broken stalks and those eaten by rats deteriorated, resulting in the poor sugar content of this variety. Judged from the previous results of variety test, C. A. C. 126 is really a cane with poor sugar content.

SUMMARY AND CONCLUSIONS

The results of this study may be summarized as follows:

1. The College seedling varieties gave just as good germination and stand as the standard varieties of sugar cane.

2. All the College seedling varieties arrow freely. C. A. C. 128, like POJ 2878, is an early and profusely flowering variety.

3. No major disease and pest was found to attack the College seedling varieties.

4. With regard to the yields of cane and sugar per hectare and yield of sugar per ton cane, of the standard varieties, P. S. A. 7 and P. S. A. 14 were found the highest yielders of cane and sugar per hectare. N. G. 24A was also a good yielder in the plant crop but was a very poor ratooner. M-1900 was the poorest variety both in the ratoon and plant crops.

5. Of the College seedling varieties, C. A. C. 117 and C. A. C. 128 were the best yielder of cane and sugar; their yields were comparable to those of POJ 2878. They were specially good ratooners. However, all the College seedlings had lower sucrose contents owing probably to the fact that they are easily affected by typhoons. C. A. C. 126 was a good yielder of cane, but it had a very low sucrose content.

6. N. G. 24A, a non-flowering variety, gave the highest yield of forage, with an average of 12.501 tons per hectare. C. A. C. 128 and POJ 2878, the early and profusely flowering varieties, gave the lowest yield of forage, with about 4 tons each per hectare.

RECOMMENDATION

Since C. A. C. 117 and C. A. C. 128 have consistently given favorable results, especially in the ratoon, when compared with leading varieties in the Philippines, such as P. S. A. 7, P. S. A. 14, and POJ 2878, sometimes even outyielding these standard varieties, and since these two College cane varieties have only been tested in very few places, it is recommended that they be tried under a variety of conditions of soil and climate. It is quite possible that they may excel the leading cane varieties in some cane districts. C. A. C. 126 may be eliminated for further test since it consistently gave a low yield of sugar.

TABLE 1

Comparative average yields of cane and sugar per hectare and sugar per ton cane of different varieties (first ratoon crop, 1934–1935)

VARIETIES	AVERAGE COMPUTED YIELD OF CANE PER HECTARE	DIFFERENCE	AVERAGE COMPUTED YIELD OF SUGAR HECTARE	DIFFERENCE	AVERAGE COMPUTED YIELD OF SUGAR PER TON CANE	DIFFERENCE
	tons	*tons*	*piculs*	*piculs*	*piculs*	*piculs*
POJ 2878 [a] ..	45.30 ± 3.70		77.57 ± 17.34		1.72 ± 0.03	
N. G. 24A ...	27.19 ± 2.05	—18.11 ± 4.23 (Significant)	46.16 ± 3.84	—31.41 ± 17.76 (Insignificant)	1.70 ± 0.03	—0.02 ± 0.04 (Insignificant)
M–1900	13.89 ± 0.41	—31.41 ± 3.72 (Very sig.)	24.84 ± 0.70	—52.73 ± 17.35 (Slightly sig.)	1.75 ± 0.02	—0.03 ± 0.04 (Insignificant)
C. A. C. 117 .	44.35 ± 2.90	— 0.95 ± 4.70 (Insignificant)	59.60 ± 3.44	—17.79 ± 17.68 (Insignificant)	1.35 ± 0.01	—0.37 ± 0.03 (Significant)
C. A. C. 126 .	45.30 ± 2.93	—	54.28 ± 2.75	—23.29 ± 17.56 (Insignificant)	1.21 ± 0.02	—0.51 ± 0.04 (Significant)
C. A. C. 128 .	53.30 ± 3.40	8.00 ± 5.02 (Insignificant)	80.29 ± 2.26	2.72 ± 17.49 (Insignificant)	1.38 ± 0.01	—0.34 ± 0.03 (Significant)
N. G. 24A [b] ..	27.19 ± 2.05		46.16 ± 3.84		1.70 ± 0.03	
M–1900	13.89 ± 0.41	—13.30 ± 2.09 (Significant)	24.84 ± 0.70	21.32 ± 3.90 (Significant)	1.75 ± 0.02	—0.05 ± 0.04 (Insignificant)
C. A. C. 117 .	44.35 ± 2.90	17.16 ± 3.55 (Significant)	59.60 ± 3.44	13.44 ± 5.16 (Insignificant)	1.35 ± 0.01	—0.35 ± 0.03 (Significant)
C. A. C. 126 .	45.30 ± 2.93	18.11 ± 3.57 (Significant)	54.28 ± 2.75	8.12 ± 4.73 (Insignificant)	1.21 ± 0.02	—0.49 ± 0.04 (Significant)
C. A. C. 128 .	53.30 ± 3.40	26.11 ± 3.97 (Significant)	80.29 ± 2.26	34.13 ± 4.46 (Very sig.)	1.38 ± 0.01	—0.32 ± 0.03 (Significant)

[a] POJ 2878 was used as basis for comparison.
[b] N. G. 24A was used as basis for comparison.

TABLE 1 (continued)

VARIETIES	AVERAGE COMPUTED YIELD OF CANE PER HECTARE	DIFFERENCE	AVERAGE COMPUTED YIELD OF SUGAR PER HECTARE	DIFFERENCE	AVERAGE COMPUTED YIELD OF SUGAR PER TON CANE	DIFFERENCE
	tons	*tons*	*piculs*	*piculs*	*piculs*	*piculs*
M–1900 [c]	13.89 ± 0.41		24.84 ± 0.70		1.75 ± 0.02	
C. A. C. 117 .	44.35 ± 2.90	30.46 ± 2.93 (Very sig.)	59.60 ± 3.44	34.76 ± 3.51 (Very sig.)	1.35 ± 0.01	—0.40 ± 0.02 (Significant)
C. A. C. 126 .	45.30 ± 2 93	31.41 ± 2.96 (Very sig.)	54.28 ± 2.75	29.44 ± 2.84 (Very sig.)	1.21 ± 0.02	—0.54 ± 0.03 (Significant)
C. A. C. 128 .	53.30 ± 3.40	39.41 ± 3.42 (Very sig.)	80.29 ± 2.26	55.45 ± 2.37 (Very sig.)	1.38 ± 0.01	—0.37 ± 0.02 (Significant)
C. A. C. 117 [d]	44.35 ± 2.90		59.60 ± 3.44		1.35 ± 0.01	
C. A. C. 126 .	45.30 ± 2.93	0.95 ± 4.12 (Insignificant)	54.23 ± 2.75	— 5.32 ± 4.41 (Insignificant)	1.21 ± 0.02	—0.14 ± 0.02 (Significant)
C. A. C. 128 .	53.30 ± 3.40	8.95 ± 4.47 (Insignificant)	80.29 ± 2.23	20.69 ± 4.12 (Significant)	1.38 ± 0.01	0.03 ± 0.02 (Insignificant)
C. A. C. 126 [e]	45.30 ± 2.93	—	54.28 ± 2.75		1.21 ± 0.02	
C. A. C. 128 .	53.30 ± 3.40	8.00 ± 4.49 (Insignificant)	80.29 ± 2 26	26.01 ± 3.56 (Very sig.)	1.38 ± 0.01	0.17 ± 0.02 (Significant)

[c] M–1900 was used as basis for comparison.
[d] C. A. C. 117 was used as basis for comparison.
[e] C. A. C. 126 was used as basis for comparison.

TABLE 2

Percentages of germination and stand of plants of different varieties of sugar cane

VARIETIES	PLOT	GERMINATION	STAND
	No.	*per cent*	*per cent*
POJ 2878	1	70.94	70.08
	2	75.31	74.89
	3	73.79	73.36
	Average	73.35	72.78
P. S. A. 7	1	57.14	56.29
	2	60.84	59.90
	3	65.59	64.21
	Average	61.19	60.13
P. S. A. 14	1	66.23	65.38
	2	75.15	73.81
	3	84.32	83.47
	Average	75.23	74.22
N. G. 24A	1	56.13	54.24
	2	65.12	63.02
	Average	60.63	58.63
C. A. C. 117	1	43.12	42.18
	2	71.05	70.17
	3	79.39	78.96
	Average	64.52	63.77
C. A. C. 126	1	49.06	46.26
	2	68.51	68.08
	3	78.57	77.31
	Average	65.38	63.88
C. A. C. 128	1	66.34	65.85
	2	66.96	66.96
	3	69.95	69.09
	Average	67.75	67.30

TABLE 3

Percentage of tasseling of different varieties of sugar cane

VARIETIES	PLOT	TASSELING
	No.	*per cent*
POJ 2878	1	90.00
	2	89.00
	3	83.00
	Average	87.33
P. S. A. 7	1	51.00
	2	43.00
	3	46.00
	Average	46.66
C. A. C. 117	1	71.00
	2	73.00
	3	67.00
	Average	70.33
C. A. C. 126	1	64.00
	2	66.00
	3	59.00
	Average	63.00
C. A. C. 128	1	95.00
	2	95.00
	3	99.00
	Average	96.33

TABLE 4

Percentages of dead and rat-infested stalks of different varieties of sugar cane

VARIETIES	STALKS COUNTED	RAT INFESTED	DEAD
	No.	*per cent*	*per cent*
POJ 2878	100	6	0
P. S. A. 7	100	1	0
P. S. A. 14	100	0	2
N. G. 24A	100	15	1
C. A. C. 117	100	7	1
C. A. C. 126	100	5	3
C. A. C. 128	100	16	4

TABLE 5

Comparative average computed yields of cane and sugar per hectare and piculs sugar per tone cane of the different varieties of sugar cane (plant crop, 1935–36)

VARIETIES	COMPUTED AV. YIELD OF CANE PER HECTARE	DIFFERENCE	COMPUTED AV. YIELD OF SUGAR PER HECTARE	DIFFERENCE	COMPUTED AV. YIELD OF SUGAR PER TON CANE	DIFFERENCE
	tons	*tons*	*piculs*	*piculs*	*piculs*	*piculs*
POJ 2878 [a] ..	55.21 ± 6.07		97.82 ± 3.94		1.83 ± 0.12	
P.S.A. 7	84.50 ± 0.49	29.29 ± 6.09 (Sig.)	163.42 ± 10.95	65.60 ± 11.64 (Sig.)	1.93 ± 0.11	0.10 ± 0.16 (Insig.)
P.S.A. 14 ...	61.48 ± 3.54	6.27 ± 7.03 (Insig.)	131.96 ± 7.11	34.14 ± 8.13 (Sig.)	2.15 ± 0.03	0.32 ± 0.12 (Insig.)
N.G. 24A ...	65.96 ± 0.95	10.75 ± 6.15 (Insig.)	111.73 ± 7.22	13.91 ± 8.22 (Insig.)	1.69 ± 0.08	—0.14 ± 0.15 (Insig.)
C.A.C. 117 ..	72.35 ± 2.86	17.14 ± 6.71 (Insig.)	111.19 ± 3.37	13.37 ± 5.18 (Insig.)	1.55 ± 0.07	—0.28 ± 0.14 (Insig.)
C.A.C. 126 ..	55.66 ± 4.26	0.45 ± 7.42 (Insig.)	83.11 ± 7.98	—14 71 ± 8.90 (Insig.)	1.48 ± 0.04	—0.35 ± 0.13 (Insig.)
C.A.C. 128 ..	70.04 ± 2.28	14.83 ± 6.49 (Insig.)	94.31 ± 8.63	— 3 51 ± 9.49 (Insig.)	1.34 ± 0.09	—0.49 ± 0.15 (Sig.)
P.S.A. 7 [b] ...	84.50 ± 0.49		163.42 ± 10.95		1.93 ± 0.11	
P.S.A. 14 ...	61.48 ± 3.54	—23.02 ± 3.57 (Sig.)	131.96 ± 7.11	—31.46 ± 13.06 (Insig.)	2.15 ± 0.03	0.22 ± 0.12 (Insig.)
N.G. 24A ...	65.96 ± 0.95	—18.54 ± 1.07 (Sig.)	111.73 ± 7.22	—51.69 ± 13.12 (Sig.)	1.69 ± 0.09	—0.24 ± 0.14 (Insig.)
C.A.C. 117 ..	72.35 ± 2.86	—12.15 ± 2.91 (Sig.)	111.19 ± 3.37	—52.23 ± 11.46 (Sig.)	1.55 ± 0.07	—0.38 ± 0.13 (Insig.)
C.A.C. 126 ..	55.66 ± 4.26	—28.84 ± 4.28 (Sig.)	83.11 ± 7.98	—80.31 ± 13.55 (Sig.)	1.48 ± 0.04	—0.45 ± 0.12 (Sig.)
C.A.C. 128 ..	70.04 ± 2.28	—14.46 ± 2.34 (Sig.)	94.31 ± 8.63	—69.11 ± 13.95 (Sig.)	1.34 ± 0.09	—0.59 ± 0.14 (Sig.)

[a] POJ 2878 was used as basis for comparison.
[b] P. S. A. 7 was used as basis for comparison.

TABLE 5 (continued)

VARIETIES	COMPUTED AV. YIELD OF CANE PER HECTARE	DIFFERENCE	COMPUTED AV. YIELD OF SUGAR PER HECTARE	DIFFERENCE	COMPUTED AV. YIELD OF SUGAR PER TON CANE	DIFFERENCE
	tons	*tons*	*piculs*	*piculs*	*piculs*	*piculs*
P.S.A. 14[c] ..	61.48 ± 3.54		131.96 ± 7.11		2.15 ± 0.03	
N.G. 24A ...	65.96 ± 0.95	4.48 ± 3.66 (Insig.)	111.73 ± 7.22	—20.23 ± 10.13 (Insig.)	1.69 ± 0.09	—0.46 ± 0.09 (Sig.)
C.A.C. 117 ..	72.35 ± 2.86	10.87 ± 4.55 (Insig.)	111.19 ± 3.37	—20.77 ± 7.87 (Insig.)	1.55 ± 0.07	—0.60 ± 0.08 (Sig.)
C.A.C. 126 ..	55.66 ± 4.26	— 5.82 ± 5.54 (Insig.)	83.11 ± 7.98	—48.85 ± 10.69 (Sig.)	1.48 ± 0.04	—0.67 ± 0.05 (Sig.)
C.A.C. 128 ..	70.04 ± 2.28	8.56 ± 4.21 (Insig.)	94.31 ± 8.63	—37.65 ± 11.18 (Sig.)	1.34 ± 0.09	—0.81 ± 0.09 (Sig.)
N.G. 24A[d] ..	65.96 ± 0.95		111.73 ± 7.22		1.69 ± 0.08	
C.A.C. 117 ..	72.35 ± 2.86	6.39 ± 3.02 (Insig.)	111.19 ± 3.37	— 0.54 ± 7.97 (Insig.)	1.55 ± 0.07	—0.14 ± 0.11 (Insig.)
C.A.C. 126 ..	55.66 ± 4.26	—10.30 ± 4.37 (Insig.)	83.11 ± 7.98	—28.62 ± 10.76 (Insig.)	1.48 ± 0.04	—0.21 ± 0.09 (Insig.)
C.A.C. 128 ..	70.04 ± 2.28	4.08 ± 2.48 (Insig.)	94.31 ± 8.63	—17.42 ± 11.26 (Insig.)	1.34 ± 0.09	—0.35 ± 0.12 (Insig.)
C.A.C. 117[e] .	72 35 ± 2.86		111.19 ± 3.37		1.55 ± 0.07	
C.A.C. 126 ..	55.66 ± 4.26	—16.69 ± 5.14 (Sig.)	83.11 ± 7.98	—28.08 ± 8.66 (Sig.)	1.48 ± 0.04	—0.07 ± 0.08 (Insig.)
C.A.C. 128 ..	70.04 ± 2.28	— 2.31 ± 3.67 (Insig.)	94.31 ± 8.63	—16.88 ± 9.27 (Insig.)	1.34 ± 0.09	—0.21 ± 0.11 (Insig.)
C.A.C. 126[f] .	55.66 ± 4.26		83 11 ± 7.98		1.48 ± 0.04	
C.A.C. 128 ..	70.04 ± 2.28	14.38 ± 4.82 (Insig.)	94.31 ± 8.63	11.20 ± 11.76 (Insig.)	1.34 ± 0.09	—0.14 ± 0.09 (Insig.)

[c] P. S. A. 14 was used as basis for comparison.
[d] N. G. 24A was used as basis for comparison.
[e] C. A. C. 117 was used as basis for comparison.
[f] C. A. C. 126 was used as basis for comparison.

TABLE 6

Yield of forage[1] *of the different varieties of sugar cane*

VARIETIES	PLOT	FORAGE	COMPUTED YIELD PER HECTARE
	No.	*kgm.*	*tons*
POJ 2878 ..	1	192.40	3.729
	2	312.20	6.122
	3	662.80	1.310
	Average	389.13	4.054
P. S. A. 7 ..	1	170.20	3.298
	2	362.20	7.032
	3	—	—
	Average	348.00	5.165
P. S. A. 14 .	1	100.00	1.931
	2	310.80	6.044
	3	367.60	7.268
	Average	259.47	5.081
N. G. 24A ..	1	534.40	10.309
	2	758.20	14.694
	Average	646.30	12.501
C. A. C. 117	1	159.40	3.078
	2	311.40	6.151
	3	688.60	13.423
	Average	386.47	7.551
C. A. C. 126	1	134.20	2.589
	2	269.80	5.229
	3	432.60	8.393
	Average	278.86	5.403
C. A. C. 128	1	110.00	2.121
	2	134.20	2.600
	3	495.00	9.615
	Average	246.40	4.780

[1] Forage refers to the top portion of sugar cane including all leaves after the cane has been topped for points.

TABLE 7

Comparative yields of cane and sugar per hectare and sugar per ton cane of the different varieties of sugar cane (first ratoon crop, 1936–37)

VARIETIES	COMPUTED AV. YIELD OF CANE PER HECTARE	DIFFERENCE	COMPUTED AV. YIELD OF SUGAR PER HECTARE	DIFFERENCE	COMPUTED AV. YIELD OF SUGAR PER TON CANE	DIFFERENCE
	tons	*tons*	*piculs*	*piculs*	*piculs*	*piculs*
POJ 2878 [a] ..	53.71 ± 4.24		81.50 ± 7.48		1.51 ± 0.02	
N.G. 24A	14.70 ± 2.08	—39.01 ± 4.72 (V.sig.)	25.17 ± 3.16	—56.33 ± 8.12 (V. sig.)	1.70 ± 0.00	0.19 ± 0.02 (Sig.)
P.S.A. 7	62.45 ± 2.76	8.74 ± 5.06 (Insig.)	104.60 ± 4.55	23.10 ± 8.75 (Insig.)	1.67 ± 0.00	0.16 ± 0.02 (Sig.)
P.S.A. 14 ...	50.56 ± 4.29	— 3.13 ± 6.03 (Insig.)	90.06 ± 3.89	8.56 ± 8.43 (Insig.)	1.81 ± 0.08	0.30 ± 0.09 (Insig.)
C.A.C. 117 ..	50.66 ± 5.84	— 3.05 ± 6.91 (Insig.)	80.66 ± 7.69	— 0.84 ± 10 73 (Insig.)	1.61 ± 0.13	0.10 ± 0.13 (Insig.)
C.A.C. 126 ..	53.89 ± 7.27	0.18 ± 8.42 (Insig.)	64.41 ± 5.60	—17.09 ± 9.34 (Insig.)	1.25 ± 0.10	—0.26 ± 0.10 (Insig.)
C.A.C. 128 ..	64.19 ± 4.92	10.48 ± 6.50 (Insig.)	86.72 ± 2.01	5.22 ± 7.74 (Insig.)	1.37 ± 0.07	—0.14 ± 0.07 (Insig.)
N.G. 24A [b] ..	14.70 ± 2.08		25.17 ± 3.16		1.70 ± 0.00	
P.S.A. 7	62.45 ± 2.76	47.75 ± 3.46 (V. sig.)	104.60 ± 4.55	79.43 ± 3.56 (V. sig.)	1.67 ± 0.00	—0.03 ± 0.00 (Sig.)
P.S.A. 14 ...	50.56 ± 4.29	35.86 ± 4.76 (V. sig.)	90.06 ± 3.89	64.89 ± 5.01 (V. sig.)	1.81 ± 0.08	0.11 ± 0.08 (Insig.)
C.A.C. 117 ..	50.66 ± 5.84	35.96 ± 6.20 (V. sig.)	80.66 ± 7.69	55.49 ± 8.32 (V. sig.)	1.61 ± 0.13	—0.09 ± 0.13 (Insig.)
C.A.C. 126 ..	53.89 ± 7.27	39.19 ± 7.56 (V. sig.)	64.41 ± 5.60	39.24 ± 6.43 (V. sig.)	1.25 ± 0.10	—0.45 ± 0.10 (Sig.)
C.A.C. 128 ..	64.19 ± 4.92	49.49 ± 5.35 (V. sig.)	86.72 ± 2.01	61.55 ± 3.75 (V. sig.)	1.37 ± 0.07	—0.33 ± 0.07 (V. sig.)

[a] POJ 2878 was used as basis for comparison.
[b] N. G. 24A was used as basis for comparison.

TABLE 7 (continued)

Varieties	Computed av. yield of cane per hectare	Difference	Computed av. yield of sugar per hectare	Difference	Computed av. yield of sugar per ton cane	Difference
	tons	*tons*	*piculs*	*piculs*	*piculs*	*piculs*
P.S.A. 7 [c] ...	62.45 ± 2.76		104.60 ± 4.55		1.67 ± 0.00	
P.S.A. 14 ...	50.56 ± 4.29	—11.89 ± 5.10 (Insig.)	80.06 ± 3.89	—14.54 ± 5.98 (Insig.)	1.81 ± 0.08	0.14 ± 0.08 (Insig.)
C.A.C. 117 ..	50.66 ± 5.84	—11.79 ± 6.46 (Insig.)	80.66 ± 7.69	—23.94 ± 8.94 (Insig.)	1.61 ± 0.13	—0.06 ± 0.13 (Insig.)
C.A.C. 126 ..	53.89 ± 7.27	— 8.56 ± 7.78 (Insig.)	64.41 ± 5.60	—40.19 ± 7.21 (Sig.)	1.25 ± 0.10	—0.42 ± 0.10 (Sig.)
C.A.C. 128 ..	64.19 ± 4.92	1.74 ± 5.66 (Insig.)	86.72 ± 2.01	—17.88 ± 4.98 (Sig.)	1.37 ± 0.07	—0.30 ± 0.07 (Sig.)
P.S.A. 14 [d] ..	50.56 ± 4.29		90.06 ± 3.89		1.81 ± 0.08	
C.A.C. 117 ..	50.66 ± 5.84	0.10 ± 7.24 (Insig.)	80.66 ± 7.69	— 9.40 ± 8.62 (Insig.)	1.61 ± 0.13	—0.20 ± 0.16 (Insig.)
C.A.C. 126 ..	53.89 ± 7.27	3.33 ± 8.44 (Insig.)	64.41 ± 5.60	—25.65 ± 6.82 (Sig.)	1.25 ± 0.10	—0.56 ± 0.13 (Sig.)
C.A.C. 128 .	64.19 ± 4.92	3.63 ± 6.54 (Insig.)	86.72 ± 2.01	— 3.34 ± 4.38 (Insig.)	1.37 ± 0.07	—0.44 ± 0.11 (Sig.)
C.A.C. 117 [e] .	50.66 ± 5.84		80.66 ± 7.69		1.61 ± 0.13	
C.A.C. 126 ..	53.89 ± 7.27	3.23 ± 9.33 (Insig.)	64.41 ± 5.60	—16.25 ± 9.52 (Insig.)	1.25 ± 0.10	—0.36 ± 0.10 (Insig.)
C.A.C. 128 ..	64.19 ± 4.92	13.53 ± 7.64 (Insig.)	86.72 ± 2.01	6.06 ± 7.95 (Insig.)	1.37 ± 0.07	—0.24 ± 0.15 (Insig.)
C.A.C. 126 [f] .	53.89 ± 7.27		64.41 ± 5.60		1.25 ± 0.10	
C.A.C. 128 ...	64.19 ± 4.92	10.30 ± 8.79 (Insig.)	86.72 ± 2.01	22.31 ± 5.95 (Sig.)	1.37 ± 0.07	0.12 ± 0.12 (Insig.)

[c] P. S. A. 7 was used as basis for comparison.
[d] P. S. A. 14 was used as basis for comparison.
[e] C. A. C. 117 was used as basis for comparison.
[f] C. A. C. 126 was used as basis for comparison.

CORROSION OF METALS BY SOME MOTOR FUELS [1]

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WITH THREE CHARTS

The fuel passageways from the tank to the carburetor in a gas engine are subject to corrosion due to the action of the motor fuel itself. It is the purpose of this paper to present data on the corrosive effect of alcohol, gasoline, kerosene, and other motor fuels on some metals that are used in the fuel feed system of internal combustion engines. The corrosion caused by the products of combustion of the fuel on the metals used in the exhaust system is not covered in this investigation.

Data showing quantitatively the corrosion of the fuel feed system by the fuel itself are difficult to obtain. It was found in the tests carried out by the London General Omnibus Company [3] from 1919 to 1920 that denatured alcohol corroded copper and iron very badly even when mixed with 50 per cent of benzol. Brass, zinc, aluminum, and tin were slightly attacked. The use of lead-coated fuel tanks and pipes was found necessary. Sheet iron or steel coated with an alloy of 20 per cent tin and 80 per cent lead was found to be resistant to the corrosive action. Heinzelmann [4] immersed lead, zinc, iron, aluminum, brass, and copper in 90 per cent denatured alcohol for two months in the dark and for three months in diffused daylight and found that lead, zinc, iron, and aluminum were badly attacked while brass and copper were corroded to a less extent. Tin was found free from corrosion. The action of the denatured alcohol was found roughly proportional to its content of wood naphtha which was used as denaturant. The higher the ester content of the wood

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[1] Experiment Station contribution No. 1208. Received for publication November 11, 1937.

[2] Formerly of the Department of Agricultural Engineering.

[3] Cited by G. W. MONIER-WILLIAMS. 1922. Power alcohol, page 267. London: Oxford Technical Publication.

[4] HEINZELMANN, G. 1904. 1905. Zeitsch. für Spiritus Industrie. No. 39. (MONIER-WILLIAMS, G. W. 1922. Power alcohol. London: Oxford Technical Publication.)

naphtha the greater was the corrosion. The combined action of water in alcohol and esters in naphtha was considered responsible for the corrosion of the metals affected by denatured alcohol.

Duchemin [5] showed in the following table the amount of dry residue obtained from one liter of alcohol after being left in contact with various metals for three months:

	IRON	TIN	ZINC	COPPER	BRASS
Ethyl alcohol, 95%	0.9	1.3	2.2	1.1	1.4
" " + 50% water	10.8	2.5	8.3	1.9	2.1
" " + 10% aldehyde	1.5	1.4	3.9	0.8	1.0
" " + 10% ethyl acetate ..	3.4	1.9	4.7	0.8	0.8
" " + 10% amyl acetate ..	1.0	1.2	8.4	2.2	3.0
Methyl alcohol, 95%	1.5	0.3	1.8	0.9	1.1
" " + 50% water	13.8	0.9	13.6	0.4	0.5
" " + 10% acetone	1.3	1.2	1.6	2.0	2.0
" " + 10% methyl acetate .	0.9	1.5	3.8	0.6	2.0

The results obtained by Duchemin confirmed to some extent the findings of Heinzelmann.

MATERIALS AND METHOD

The metals used in the present investigation were as follows: (*a*) mild steel, (*b*) cast iron, (*c*) aluminum, (*d*) lead, (*e*) copper, and (*g*) galvanized iron. They all measured about 5 cm. × 5 cm. × 0.65 cm., except galvanized iron, which was 0.1 cm. thick. The dimensions, weights, volumes, areas, and specific gravities of the metals used are shown in table 1. Note that the volume of the galvanized iron is only about 1/6 the volume of the other metals.

The motor fuels used were numbered as follows:

(1) Alcohol motor fuel. This contains 100 parts by volume of 95 per cent ethyl alcohol and 3 parts by volume of commercial gasoline (Commercial fuel).

(2) B-dehydrated alcohol. About 98.5 per cent by volume of ethyl alcohol denatured with about 5 per cent sulfuric ether (Commercial fuel).

(3) Ethyl alcohol 190° proof

(4) Ethyl alcohol 180° proof

(5) Methyl alcohol—c. p., sp. gr. = 0.796

(6) Benzine—sp. gr. = 0.880

(7) Acetone—sp. gr. = 0.799

(8) Commercial ether—sp. gr. = 0.720.

(9) Gasanol—Contains 50 parts by volume of 95.5 per cent ethyl alcohol, 45 parts by volume of commercial gasoline, and 5 parts by volume of sulfuric ether, sp. gr. 0.730.

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[5] DUCHEMIN, R. P. 1909. Seventh Internat. Congress. Appl. Chem. London. (MONIER-WILLIAMS, G. W. 1922. Power alcohol. London: Oxford Technical Publication.)

(10) Gastarla—Contains 60 parts by volume of 96 per cent ethyl alcohol, 35 parts by volume of gasoline, and 5 parts by volume of benzol.

(11) Gasoline—Ordinary commercial gasoline

(12) Kerosene—Commercial kerosene

Two pieces of each metal were used for each fuel. The pair was placed inside a wide-mouthed Mason jar. Enough fuel was placed inside each jar to cover the whole surface areas of the pieces. About 200 ml. of each fuel was used for each container. The mouths of the jars were not tightly covered. All the jars were kept inside a covered cabinet. Every other day the contents of the jars were shaken. Additional amount of fuel was added to each jar to provide for any loss due to evaporation.

Immersions were made for periods covering 100 days (two trials), 200 days, and 350 days. The metals were weighed before and after each immersion period. Fresh fuels were used for each period. Changes in the motor fuel and in the metals were noted and recorded.

The amount of corrosion was computed in three different ways: (1) loss of weight per given time, (2) decrease in volume per given time, and (3) percentage based on change of weight per given time.

The investigation was conducted in the fuel laboratory of the Department of Agricultural Engineering, College of Agriculture, between March, 1934, and July, 1936.

RESULTS AND DISCUSSION

The amount of corrosion cumulative for 100 days, 200 days, 400 days, and 750 days are given in tables 2 and 3 and in charts 1, 2, and 3. The conditions of the metals and of the motor fuels as observed after 100-days immersion are given in tables 4 and 5.

Mild steel was heavily corroded by ether. Corrosion of mild steel by the alcohol fuels was found nearly proportional to the amount of water present in the fuel. The degree of corrosion caused by the alcohol-gasoline mixtures was nearly the same as that caused by 90 per cent ethyl alcohol. The action of benzol, gasoline, kerosene, and dehydrated alcohol on mild steel was very slight. Rusting was evident whenever mild steel showed signs of corrosion.

Cast iron was also heavily corroded by ether. The effects of the different fuels on cast iron would be practically the same as those on mild steel except that the degree of corrosion in cast iron was smaller than in mild steel. Rusting was also in evidence whenever corrosion occurred.

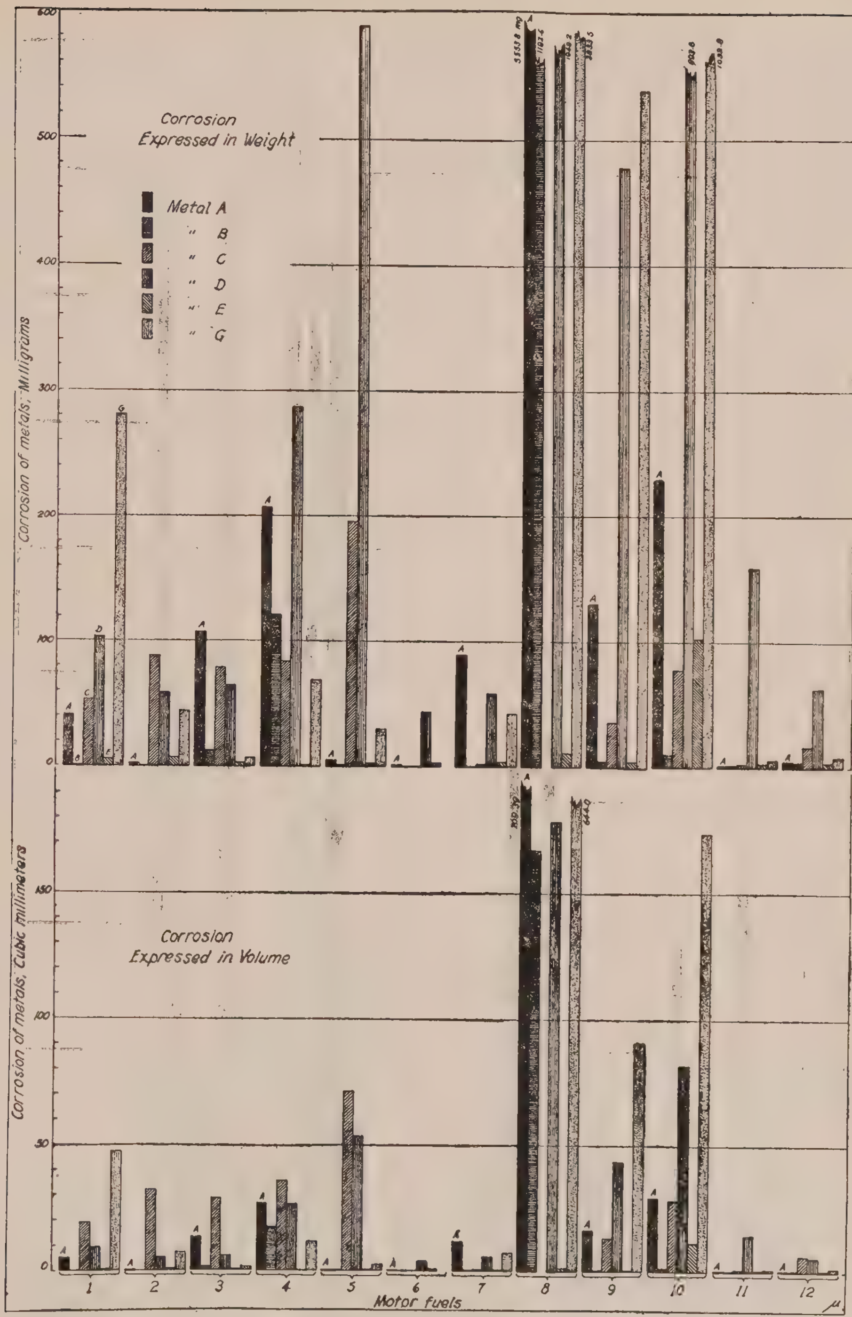

Chart 1.—Corrosion, expressed in weight and volume, of mild steel (*A*), cast iron (*B*), aluminum (*C*), lead (*D*), copper (*E*), and galvanized iron (*G*)

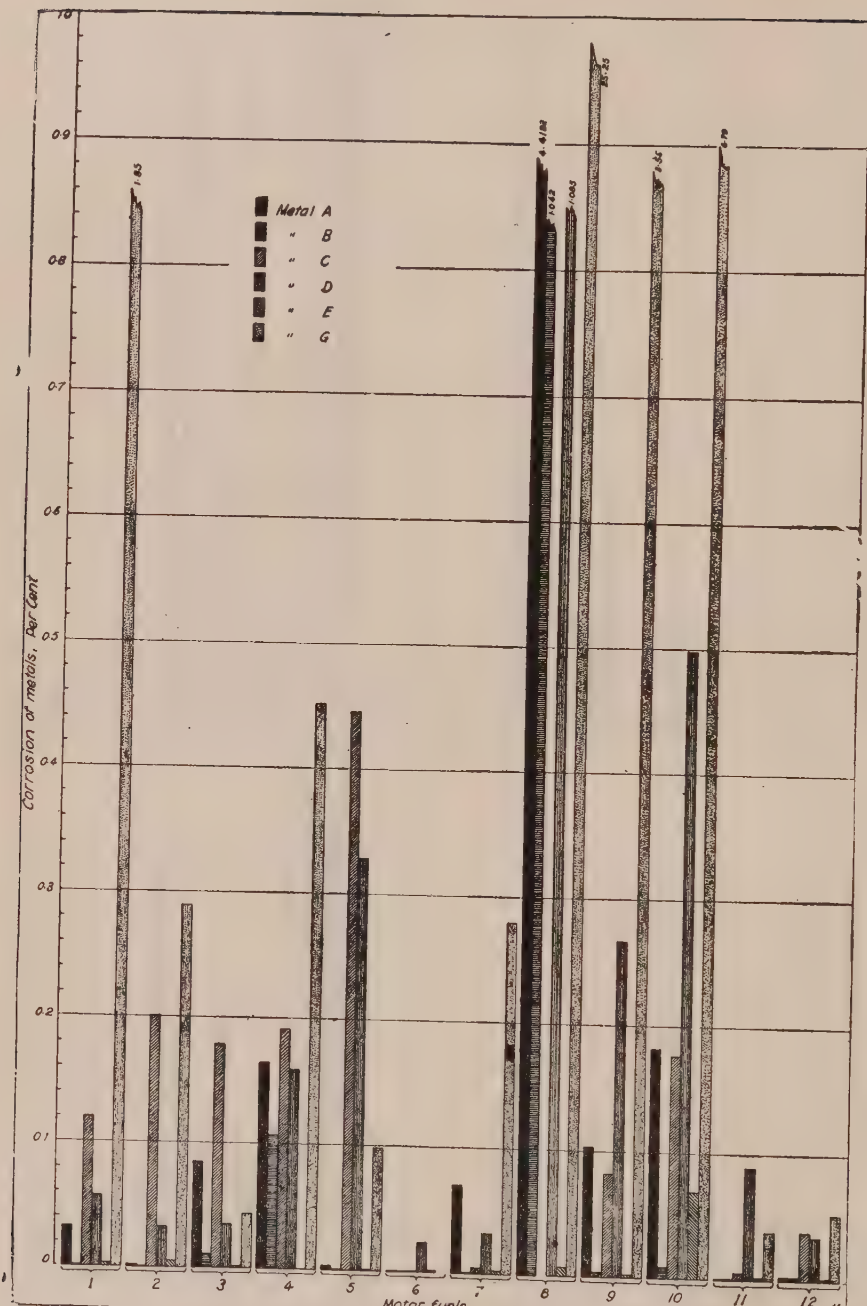

Chart 2.—Percentage corrosion of mild steel (A), cast iron (B), aluminum (C), lead (D), copper (E), and galvanized iron (G)

Aluminum was heavily attacked by methyl alcohol. Corrosion caused by ether, benzol, gasoline, and kerosene was slight. The action of the alcohol fuels was moderately heavy and showed greater corrosion where the amount of water content was high. A deposit of a jelly-like substance was present wherever corrosion was in evidence. This substance was held in suspension. Its color varied

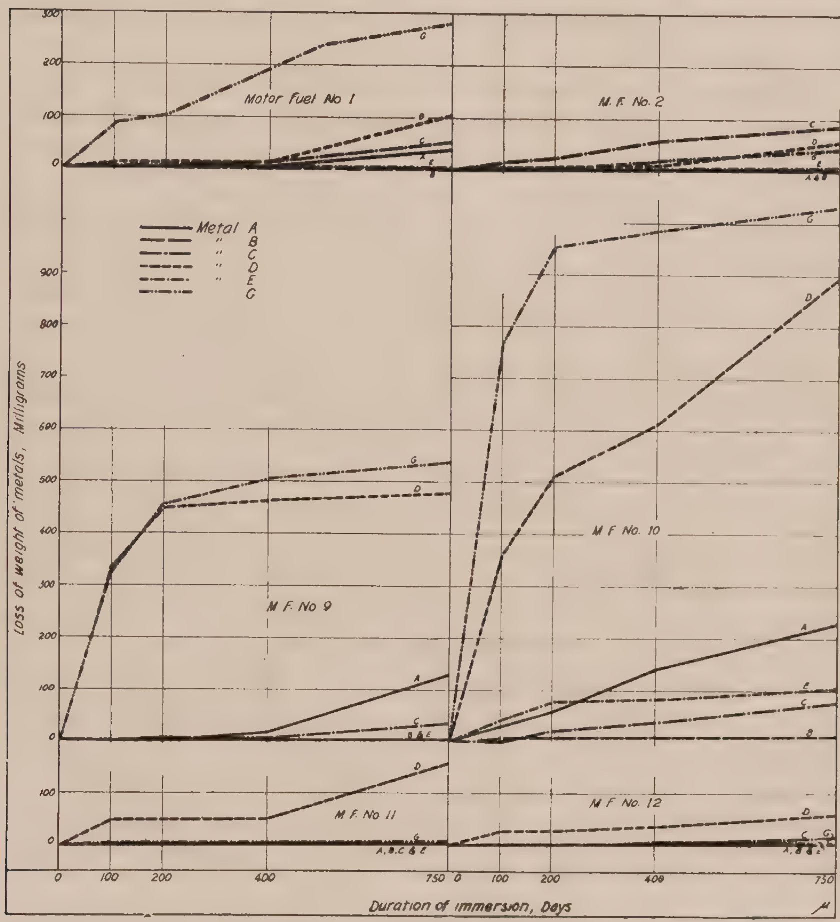

Chart 3.—Corrosion at different periods of immersion of the metals in alcohol motor fuel (M. F. No. 1), B-dehydrated alcohol (M. F. No. 2), Gasanol (M. F. No. 9), Gastarla (M. F. No. 10), kerosene (M. F. No. 11), and gasoline (M. F. No. 12)

from white to gray. The fuel turned dark in the test jar containing the mixture of gasoline, alcohol, and benzol.

Lead was heavily attacked by ether. It was moderately corroded by the alcohol fuels. Methyl alcohol also corroded lead heavily.

Practically all the fuels used corroded lead to some extent. The surface of the metal turned dark when alcohol fuels were used in the tests. A gray deposit was found in the test jars containing methyl alcohol. Yellowish coating was noticed in the jars containing gasoline and kerosene.

Copper was the least corroded of all the metals used. Only a slight dark coating was observed on the surface of the metal under certain conditions.

Galvanized iron was the most affected of all the metals used. The heaviest corrosion was caused by ether. Benzine produced no effect at all. The action of the alcohol fuels on galvanized iron was as heavy as on aluminum. A white coating was observed on the surface of the metal whenever corroded. The liquid showed turbidity in some cases. Where the corrosion was heavy, rust was also observed. It is believed that rusting occurred when the tin coating of the iron was removed and the steel portion of the metal was exposed.

With regard to the corrosion of all the metals tested in which alcohol fuels were used, the results obtained in the present investigation confirm the findings of Heinzelmann. Difference in the degree of corrosion was noted on lead and on copper when compared with the results obtained by the London General Omnibus Company. Copper was reported badly attacked and lead only slightly attacked in the London General Omnibus Company's tests, while in the present investigation and in the tests carried by Heinzelmann, copper was found only slightly affected and lead heavily attacked.

Five years of observation by the senior author on the corrosive effect of alcohol fuels in the tanks of various automobiles and in tanks used for fuel storage showed that old galvanized iron was readily and heavily attacked. The surface of some new tanks that were made of sheet iron was found to remain bright even after six months of use. Tanks that had been used to store gasoline were found easily corroded.

Incipient rusting was observed in old galvanized iron tanks after about three months and in some new tanks after about six months of use. Clogging of the fuel screen by rust was observed from about six months to about a year after alcohol fuel was used. This trouble occurred two or three times in some cars at intervals of about three months during the first two years of using alcohol. The rust came from the fuel and vacuum tanks. In the third year of service no more trouble of this kind was noted.

The copper tubing of the fuel feed system did not show evidence of corrosion. The iron portion of some carburetors that came in contact with the alcohol fuel was rusted. The float and jets which were made of copper were only slightly stained but were not corroded in some cars. In other cars, where the floats were made of very thin copper, rusting caused perforations in the float. Aluminum carburetors were attacked. A thick jelly-like deposit was observed in some aluminum carburetor bowls.

Corrosion due to mixtures containing alcohol and gasoline was very heavy on galvanized iron tanks and on aluminum carburetors. This was true especially in mixtures where sulfuric ether or benzol was used as blends and where the amount of gasoline in the mixture was from 40 to 50 per cent by volume. A heavy deposit of corroded metals was observed in the bottom of tanks where mixtures of these kinds were stored for two years. Troubles due to clogging of carburetor jets occurred in some aluminum carburetors. The action caused by the mixtures was in general faster than that caused by nearly straight alcohol.

Copper oil cans which were used for priming small stationery engines using alcohol were also observed to be badly attacked by alcohol fuels when the liquid was kept in the cans for over six months. Ordinary kerosene cans showed evidence of corrosion about three months after alcohol had been stored in them. Galvanized iron tubings were attacked when used in the fuel feed system.

SUMMARY AND CONCLUSIONS

1. Mild steel and cast iron are readily and heavily corroded by ether. They show signs of rusting soon after corrosion starts. Corrosion of these metals by the alcohol fuels shows that the higher the water content of the fuel the greater the corrosion. Alcohol fuels containing ether as an admixture are highly corrosive to these metals.

2. Aluminum is heavily corroded by methyl alcohol. It is easily attacked by alcohol fuels and by fuels containing alcohol as an admixture. When corroded, it forms a jelly-like substance which may clog the fuel passageways and carburetor jets.

3. Lead is heavily attacked by ether and by methyl alcohol and is corroded by all the fuels used in the test.

4. Copper is the only metal tested that is least affected by corrosion.

5. Galvanized iron is corroded by all the fuels used except by benzine. It is heavily attacked by ether and by alcohol fuels, especially those containing gasoline and ether as admixtures.

TABLE 1

Measurements of the metals used

METALS	AVERAGE WEIGHT	AVERAGE MEASUREMENTS			VOLUME	SURFACE AREA	SPECIFIC GRAVITY
		Length	Width	Thickness			
	gm.	*cm.*	*cm.*	*cm.*	*cc.*	*sq. cm.*	
A	125.8706	5.010	5.031	0.638	16.0810	63.1	7.83
B	113.4087	4.996	4.992	0.642	16.0115	62.7	7.08
C	43.8395	4.980	4.959	0.647	15.9782	62.2	2.74
D	179.3139	4.991	5.036	0.653	16.4129	63.5	10.92
E	148.5072	5.118	5.108	0.654	17.0974	65.6	8.69
G	15.1899	5.137	5.125	0.097	2.5537	53.3	5.95

TABLE 2

Loss of weight of metals after different periods of immersion in different kinds of motor fuels

DURATION OF IMMERSION	METALS	MOTOR FUELS 1	2	3	4	5	6	7	8	9	10	11	12
		mg.	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
After 100 days	A	2.60	1.00	0.50	74.95	0.00	1.15	86.25	107.75	0.05	31.35	0.00	2.45
	B	0.55	0.30	0.00	60.05	0.00	0.00	0.00	48.85	2.70	8.90	0.00	3.30
	C	0.00	15.85	2.00	19.25	0.90	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	D	10.35	5.05	7.55	92.00	361.75	12.40	7.25	36.95	337.75	358.75	48.75	29.65
	E	2.20	1.40	2.45	0.30	1.95	0.00	1.00	0.00	1.25	42.75	0.25	0.25
	G	89.40	0.15	2.90	42.00	11.10	0.00	41.05	736.50	324.60	767.50	4.05	0.00
After 200 days	A	2.60	1.00	0.50	89.70	0.00	1.15	86.25	1347.25	0.05	58.35	0.00	2.45
	B	0.55	0.30	0.00	60.05	0.00	0.00	0.00	842.35	2.70	8.90	0.00	3.30
	C	2.75	24.35	8.25	26.75	30.65	0.20	0.00	0.00	6.25	20.75	0.00	3.75
	D	10.35	5.05	8.55	151.00	361.75	12.90	7.25	53.20	448.50	512.75	50.75	29.65
	E	2.20	1.90	2.45	0.30	1.95	0.00	1.00	0.00	1.25	76.00	0.25	0.25
	G	102.65	1.15	4.15	50.00	11.85	0.00	41.05	2118.50	457.85	952.50	4.30	4.00
After 400 days	A	2.85	1.00	98.50	136.20	0.00	1.15	86.75	4858.25	18.05	142.10	0.00	2.45
	B	0.55	0.30	9.25	102.55	0.00	0.00	0.00	1037.35	2.70	8.90	0.00	3.30
	C	13.00	58.10	46.25	38.55	82.40	0.20	0.00	0.00	7.25	38.75	0.00	3.75
	D	12.10	10.30	9.80	184.00	390.00	14.90	7.25	1760.20	463.00	612.00	50.75	39.40
	E	2.20	4.40	2.45	0.30	1.95	0.50	1.50	0.75	2.25	82.00	1.50	2.75
	G	238.90	21.90	5.65	53.25	12.60	0.00	42.55	2828.50	506.35	984.25	5.80	8.00
After 750 days	A	40.70	2.55	106.80	207.40	5.05	1.70	88.55	5553.75	130.40	228.80	2.15	4.55
	B	0.55	0.30	13.00	121.75	1.75	0.60	0.35	1182.55	4.75	10.45	1.95	4.10
	C	52.50	87.90	78.40	83.85	194.90	0.20	2.10	0.00	36.10	77.20	2.65	16.80
	D	102.45	58.70	64.60	286.90	589.90	43.45	58.55	1948.20	478.00	893.60	159.00	63.00
	E	5.10	7.25	3.20	1.35	2.60	2.85	4.10	11.25	4.05	102.55	3.20	3.90
	G	281.10	44.00	6.70	68.50	14.90	0.00	42.55	3833.50	539.15	1032.75	5.80	8.00

TABLE 3

Corrosion of the metals after 750 days of immersion in the motor fuels expressed in weight, volume, and per cent [a]

	METALS	MOTOR FUELS											
		1	2	3	4	5	6	7	8	9	10	11	12
Corrosion in milligrams	A	40.7	2.6	106.8	207.4	5.1	1.7	88.6	5553.8	130.4	228.8	2.2	4.6
	B	0.6	0.3	13.0	121.8	1.8	0.6	0.4	1182.6	4.8	10.5	2.0	4.1
	C	52.5	87.9	78.4	83.9	194.9	0.2	2.1	0.0	36.1	77.2	2.7	16.8
	D	102.5	58.7	64.6	286.9	589.9	43.5	58.6	1948.2	478.0	893.6	159.0	63.0
	E	5.1	7.3	3.2	1.4	2.6	2.9	4.1	11.3	4.1	102.6	3.2	3.9
	G	281.1	44.0	6.7	68.5	14.9	0.0	42.6	3833.5	539.2	1032.8	5.8	8.0
Corrosion in cubic millimeters	A	5.19	0.33	13.65	26.49	0.65	0.22	11.30	709.29	16.66	29.22	0.27	0.58
	B	0.08	0.04	1.84	17.21	0.25	0.08	0.05	167.20	0.67	1.48	0.28	0.58
	C	19.14	32.08	28.61	30.59	71.20	0.07	0.73	0.00	13.17	28.18	0.97	6.13
	D	9.38	5.37	5.90	26.25	53.85	3.97	5.35	178.20	43.75	81.70	14.54	5.76
	E	0.59	0.84	0.37	0.16	0.30	0.33	0.47	1.30	0.47	11.32	0.37	0.45
	G	47.25	7.39	1.13	11.52	2.55	0.00	7.15	644.00	90.70	173.70	0.98	1.34
Corrosion in per cent	A	0.0323	0.0020	0.0850	0.1645	0.0040	0.0014	0.0703	4.4123	0.1037	0.1819	0.0017	0.0036
	B	0.0005	0.0003	0.0115	0.1073	0.0015	0.0005	0.0003	1.0420	0.0042	0.0092	0.0017	0.0036
	C	0.1198	0.2006	0.1790	0.1913	0.4450	0.0005	0.0048	0.0000	0.0824	0.1763	0.0061	0.0383
	D	0.0572	0.0327	0.0359	0.1598	0.3285	0.0242	0.0326	1.0850	0.2665	0.4980	0.0886	0.0351
	E	0.0034	0.0049	0.0022	0.0009	0.0018	0.0019	0.0028	0.0076	0.0027	0.0691	0.0022	0.0026
	G	1.8500	0.2892	0.0441	0.4515	0.0981	0.0000	0.2795	25.2500	3.5500	0.7900	0.0382	0.0527

[a] Per cent based on loss of weight per given time

TABLE 4

Condition of metals after immersion for 100 days

FUELS	A	B	C	D	E	G
1	Very slight rusting	With very slight rusting	With jelly-like deposit, corroded all over	Surface slightly darkened	With a very slightly dark coating	With slightly white mass coating; metal corroded
2	No change visible	No change visible	"	"	With dark powdery deposit on surface; metal stained dark	Very slight corrosion
3	With slight rusting	With slight rusting	"	"	No change visible	"
4	With greater rusting than No. 3	With greater rusting than No. 3	"	"	"	With slight white mass coating, like No. 1
5	No notable change visible	No notable change visible	"	With gray deposit on surface	"	No notable change visible
6	"	"	No change visible	No notable change visible	"	"
7	With slight dark spots	"	"	"	No notable change visible	"
8	Very heavily attacked	Very heavily attacked	"	Corroded all over	Slightly attacked; metal stained black	Very heavily attacked
9	With slight rusting, like No. 3 or 4	With slight rusting, like No. 3 or 4	Corroded all over	"	"	Slightly attacked
10	"	"	"	"	Corrosion heavier than No. 8 or 9; metal stained black	Heavily attacked
11	No change visible	No change visible	No change visible	With very slightly yellowish coating	No notable change visible	No change visible
12	"	"	"	"	"	"

TABLE 5

Condition of motor fuels after the test of 100-day period

FUELS	A	B	C	D	E	G
1	With a small amount of rust suspension; otherwise clear	Clear, colorless	With jelly-like white suspension; liquid colorless	Clear, colorless	Clear, colorless	Slightly turbid; liquid colorless
2	Clear, brown colored	Clear, brown colored	With small amount of jelly-like white suspension; liquid yellowish	Clear, colorless	Clear, colorless	Slightly turbid; liquid brownish
3	Clear, colorless	Clear, colorless	With jelly-like white suspension; liquid colorless	Clear, colorless	Clear, colorless	Slightly turbid; liquid colorless
4	With rust suspension	With a slight rust suspension	With jelly-like white suspension; liquid colorless	Clear, colorless	Clear, colorless	Turbid with slight rust suspension
5	Clear, colorless	Clear, colorless	With jelly-like white suspension; liquid colorless	Turbid, colorless	Clear, colorless	Clear, colorless
6	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless
7	Clear, slightly yellow	Clear, slightly yellow	Clear, colorless	Clear, colorless	Clear, yellowish	Clear, colorless
8	With a large amount of rust suspension; cover of container attacked	With a large amount of rust suspension; cover of container attacked	Clear, colorless; cover of container attacked	Turbid; cover of container attacked	Turbid; cover of container attacked	With large amount of rust suspension; cover of container attacked

TABLE 5 (continued)

FUELS	A	B	C	D	E	G
9	With rust suspension; an upper layer of fuel visible	With rust suspension; an upper layer of fuel visible	With slight, jelly-like suspension; liquid colorless	Turbid, with an upper oily layer visible	Clear, colorless	With rust suspension; liquid oily
10	With rust suspension slightly turbid yellow; an upper layer of fuel visible	With rust suspension slightly turbid yellow; an upper layer of fuel visible	With slight, jelly-like suspension; liquid dark colored	Turbid, with an upper oily layer of fuel visible	Liquid dark colored	With rust suspension; liquid oily
11	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless
12	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless	Clear, colorless

DISEASES OF COTTON IN THE PHILIPPINES: II. ANTHRACNOSE, SORESHIN, AND FUSARIUM STEM AND BOLL ROT[1]

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WITH SIX TEXT FIGURES

GEOGRAPHICAL DISTRIBUTION AND ECONOMIC IMPORTANCE

Anthracnose. Cotton anthracnose first attracted attention in 1891 when Southworth (1890, 1891) and Atkinson (1891, 1892) worked on the disease. According to Ludwig (1925), the disease is now present throughout the cotton belt of the United States. It is also reported from British Guiana (Bartlett, 1907), West Indies (Lewton-Brain, 1903), British West Africa (Penzer, 1920), Egypt (Balls, 1919), India, West Indies, South West Africa, Bulgaria, and Trans-Caucasia (Butler, 1918). Birmingham and Hamilton (1923) likewise report cotton anthracnose as occurring in New South Wales, Australia.

The United States Department of Agriculture Plant Disease Reporter (1918, 1919, 1920, 1922, 1924) states that during the period from 1917 to 1921 the American cotton belt suffered losses ranging from 1.6 to 3.9 per cent; the average was 2.8 per cent, or about 358,000 bales. In 1923 all cotton diseases in the United States combined caused a reduction in yield of 2,439,000 bales. Nearly one-tenth of this loss, or 229,000 bales, was attributed to anthracnose alone. Lehman (1925) estimates the loss from anthracnose to North Carolina cotton producers in 1923 as 36,000 bales.

In the Philippines, Welles in 1921 reported that anthracnose was serious on the bolls of cotton at Los Baños. No estimate of losses caused by the disease, however, was made by him.

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[1] Experiment Station contribution No. 1209. The data on anthracnose were obtained from the thesis entitled, "A study of the anthracnose of cotton occurring in the College of Agriculture" presented by Kan Jalavicharana for graduation, October, 1936. The data on Fusarium stem and boll rot were taken from the thesis entitled, "Stem rot of cotton seedlings" presented by Romeo C. Espino for graduation, March, 1937. Both theses were conducted in the Department of Plant Pathology under the direction of Associate Professor G. O. Ocfemia. The work on the soreshin was performed by Martin S. Celino. Received for publication December 1, 1937.

Fusarium stem and boll rot. Woodroof (1927) of the Georgia Experiment Station reports a disease of cotton caused by *Fusarium moniliforme* Sheldon. The most important symptoms of the disease noted were dwarfing of the cotton plants and in most cases girdling of the stem just below the surface of the soil. Pratt (1926) also mentions having found *F. moniliforme* in rotted embryos of cotton seeds from Queensland. The *Fusarium* disease of cotton was first reported in the Philippines in 1936. Since then the disease has been occasionally observed in the field and in the cotton cultures of the Department of Plant Pathology.

Soreshin. This disease was first reported in Alabama by Atkinson (1892) and subsequently in Egypt by Fletcher (1902), Balls (1906), Fahmy (1931), and others. Fahmy concludes that soreshin is caused by numerous factors, temperature and soil conditions being among the most important, and *Rhizoctonia* sp. and various soil organisms being the immediate causes. West (1930) reports the disease in Trinidad and attributes it to *Rhizoctonia solani.* Swainson-Hall (1923) describes soreshin briefly as occurring in West and Southwest Africa and mentions *Pythium debaryanum* Hesse (?) as the possible cause of the disease. In 1934, soreshin was observed in the cotton plantings of the Department of Plant Pathology of the College of Agriculture. It attacks the plants on the stem close to the ground, often killing young cotton seedlings in 48 hours.

SYMPTOMS

Anthracnose. The seedlings which emerge from seeds badly infected with anthracnose may damp-off and rot. Seedlings with slight infections show lesions on the cotyledons. These lesions sometimes coalesce and involve the entire seedlings.

Anthracnose on the leaves starts from any point but usually at the margin. Young leaves are more readily infected than old ones. The leaves appear as if scalded. They soon wither and dry up.

The stems of cotton infected with anthracnose turn dark colored and gradually dry out. Sometimes the infected area splits or cracks. Owing to the weakening of the tissues of the parts affected, the weight of the leaves makes the young stems break and the plants fall over.

The most serious and characteristic form of anthracnose occurs on cotton bolls. One or more dark colored sunken spots may appear on the bolls. These spots are surrounded by a more or less indefinite reddish margin. The spots increase in size. In a short time the

sunken center of the spots becomes covered with a flesh-salmon-colored mass of spores (fig. 1). The formation of spores is more rapid during wet weather than during dry days. The spores are produced in small pustules which break through the epidermis and form acervuli. The pustules are very numerous, and when they break open, they run together and appear as a solid mass of spores in the center of the sunken spot. The color of the spots depends upon the amount of spores produced. If only a few spores are produced,

Fig. 1.—Cotton bolls showing different stages of anthracnose infection. The spots are dark colored, sunken, and surrounded by indefinite reddish margin. Flesh-salmon colored mass of spores developed in the center of the spots.

the center of the spot appears grayish. If large numbers of spores are produced the spots are bright salmon-pink. When the masses of spores disappear, irregularly defined spots are left.

The damage to the bolls depends upon the stage in the development of the fruit when infected by the fungus. The growth of the infected parts of the capsules is either retarded or completely checked.

The invaded tissues become dry and hard and cause the segments of the locks to crack through the diseased areas (fig. 2). On account of the cracking of the capsules, the immature cotton bolls are exposed to rain and dew and to the attack of insects. The capsules often appear water-soaked and are covered with various fungi. The anthracnose fungus, as well as the other associated fungi, often reach the fibers. When this happens, the exposed portions of the fibers may be covered either with a pinkish mass of spores or white filaments and different colors of spores of various fungi. As a consequence, the cotton fibers and seeds decay very rapidly.

Fusarium stem and boll rot. The *Fusarium* disease attacks cotton seedlings, flowers, and bolls. It causes dry rot. Young infections on seedlings appear as distinct brown lesions on the stem close

Fig. 2.—Cotton bolls infected with anthracnose. Note that the segments of the locks cracked through the diseased areas.

to the ground. Ordinarily, the lesions do not affect more than the outer layers of the stem (fig. 3, *a*). Occasionally, however, severe infections affect the root system (fig. 3, *b*). Infected seedlings do not usually die, but they remain unhealthy and very much stunted in growth. The fungus is virulent and serious on the flowers and immature bolls. Infected flowers and young bolls readily rot, turning dark brown to almost black (fig. 4, *b*). Older bolls, though infected, rot slowly and may continue to open. The lint, however, is discolored (usually pinkish) by the fungus. Under moist conditions the fungus forms a pink covering of spore masses on the boll (fig. 4, *a*).

Soreshin. The disease attacks cotton seedlings severely. It causes wet rot. Under humid conditions, the fungus grows fast on the stem close to the ground and covers it with fast spreading hyphal threads. The stems rot or become girdled and break down (fig. 5).

Young cotton plants are often killed soon after infection. The leaves of the plant subsequently wilt and dry out. Sometimes the entire upper portion of the plant topples over and rots on the ground.

CAUSAL ORGANISMS

Methods of isolation

In the isolation of the anthracnose fungus, *Glomerella gossypii* (Southw.) Edgerton, and of *Fusarium moniliforme* Sheldon var.

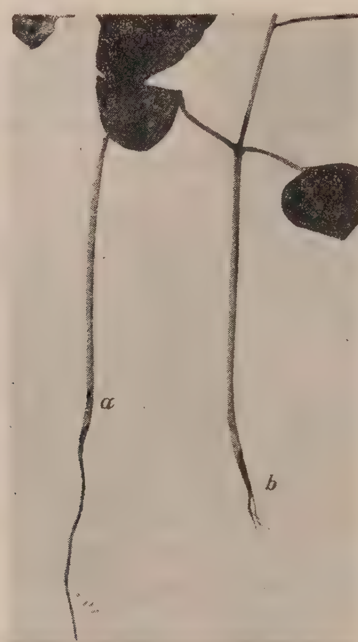

Fig. 3.—Stems of cotton seedlings infected with Fusarium moniliforme var. majus: (*a*) infection of the outer layers of the stem, (*b*) infection of the roots

majus Wollenweber et Reinking both the tissue-culture and the spore-dilution methods were followed. With the soreshin fungus, *Rhizoctonia solani* Kühn, however, only the tissue-culture method was used.

Morphology

Glomerella gossypii: *a. Mycelium.* The mycelium is fine, branched, septate, colorless when young and light brown when old. The cells are from 7.0 to 52.5 μ by 2.8 to 8.75 μ.

b. Acervuli. The acervuli are formed in groups sub-epidermally on cotton bolls and other parts of the host. When the epidermis of the host breaks, these acervuli are exposed. Each acervulus is represented by a tuft of conidiophores. The acervuli measure from 17.5 to 87.5 μ in diameter.

c. Setae. The setae are olivaceous to dark brown, either straight, curved or flexuous, and rarely branched. They measure from 70.0 to 135.5 by 3.3 to 3.7 μ; the average is 105.5 by 3.5 μ.

Fig. 4.—Cotton flowers and bolls infected with Fusarium moniliforme var. majus: (*b*) Infected flowers and young bolls and (*a*) infected bolls with pinkish fungous growths on the diseased areas

d. Conidiophores. The conidiophores are hyaline, continuous or septate, variable in size but rarely branched. They appear as short branches of the individual mycelium with the spores at their free ends. Measurements of the lengths and widths show that they are 10.5 to 35.0 by 2.1 to 3.7 μ; the average is 21.0 by 3.3 μ.

e. Conidia. The conidia are produced successively at the tips of the conidiophores. They are non-septate, oblong with rounded ends,

nearly cylindrical, granular with thin wall, hyaline under the microscope, but in masses they are salmon-pink.

The conidia are 8.75 to 20.0 by 3.5 to 6.2 μ with an average of 13.9 by 3.91 μ. They germinate readily in water within 24 hours. At germination they become uniseptate. Chlamydospore-like bodies or appressoria-like structures are produced at the ends of the germ

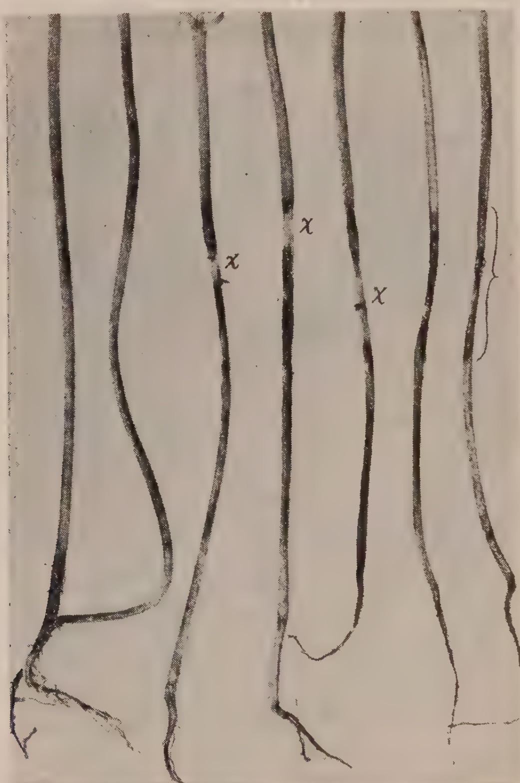

Fig. 5.—Stems of cotton seedlings with sore-shin. The stems rotted and were girdled at various places. The two stems on the left are healthy.

tubes. They are probably hold-fast organs as maintained by Hasselbring (1906) and others.

Fusarium moniliforme var. majus: *a. Mycelium.* The mycelium is septate, hyaline, granular when young but vacuolate when old. The color [2] on the various agar media ranged from white to pale

[2] The color nomenclature is after RIDGWAY, R. 1912. Color standards and color nomenclature. 43 p. *53 colored pl.; 1115 named colors.* Washington, D.C.

Persian lilac, pale brownish vinaceous red, pale grayish blue violet, pale aniline lilac, cameo pink, and pale hortense violet. The submerged mycelium ranged from lavender to hyssop violet and cinnamon buff. According to the fundamentals in the taxonomy of the genus *Fusarium* by Wollenweber, Sherbakoff, Reinking, Johann, and Bailey (1925), this submerged gelatinous growth in general indicates

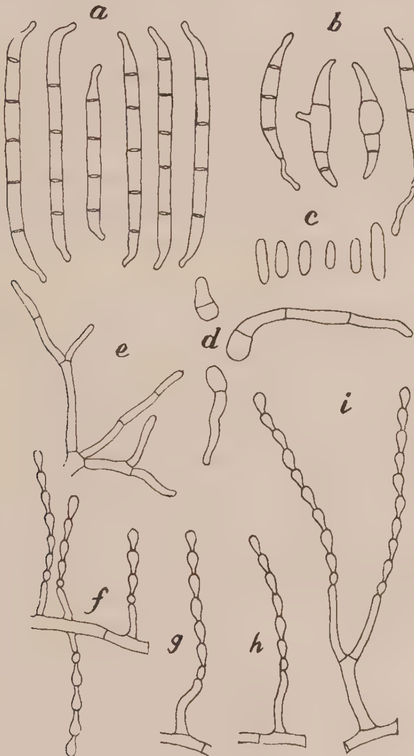

Fig. 6.—The fungus, Fusarium moniliforme var. majus: (*a*) macroconidia, (*b*) germinating macroconidia, (*c*) microconidia, (*d*) germinating microconidia, (*e*) conidiophores, (*f*-*i*) microconidia in chains

degeneration and self digestion accompanied by abnormal spore formation or even sterility of the fungus.

b. Conidiophores. The conidiophores are simple or branched. The branching of the conidiophores is as a rule ternate (fig. 6, *e*).

Microconidia. The microconidia are ovoid-fusoid, produced in chain or monoliform formation characteristic of the species (fig. 6,

f-i). They are continuous, thin-walled, and hyaline. The average size of the microconidia is 7.6 to 10.5 by 2.55 to 2.97 μ.

Macroconidia. The macroconidia (fig. 6, *a*) are produced abundantly on potato-dextrose agar, potato plugs, potato agar, oatmeal agar, rice-meal agar, and corn-meal agar. On old potato-dextrose agar macroconidia developed in abundance in *sporodochia* and in *pionnotes*. The spores are 1- to 5- (rarely 6-) septate with those of three septa predominating. They are slender, delicate, hyaline, sickle-shaped, and granular. The average size of the macroconidia is 28.9 to 70.4 by 2.97 to 3.4 μ. Both the macro- and the microconidia germinate directly (fig. 6, *b* and *c*).

Chlamydospores have not been observed in culture. The absence of chlamydospores is one of the distinguishing characteristics of the Section Liseola of the genus *Fusarium* to which this causal fungus belongs.

Rhizoctonia solani: *a. Mycelium.* The mycelium is septate, branched, and light to dark brown in color with age. The hyphal cells vary from 4 to 12 μ in width, and from 31 to 245 μ in length.

b. Sclerotial bodies. The sclerotial bodies are not always abundantly produced in culture. The fungus, instead, produces dark brown mats of hyphae. The sclerotial bodies produced on oatmeal agar are hard, dark brown, very irregular with rough sponge-like surface, flattened more or less on one side and rounded on the other. They vary in diameter from 1 to 4 millimeters, average 2.64 millimeters.

Growth on agar media and on sterilized plant tissues

Glomerella gossypii. This fungus grows well on many agar media especially where dextrose has been added and on sterilized plant-tissues. The mycelium is at first cottony white and fine, turning pale-olive-gray with age, with the submerged hyphae usually dark-ivy-green. After 5 to 6 weeks the culture appears black.

Conidia appear as salmon-pink masses on the agar slants. No perithecium and setae are produced, but chlamydospore-like bodies appear abundantly in old cultures. Atkinson (1891) states that on nutrient agar *Colletotrichum gossypii* does not produce setae as abundantly as on the host. Lewton-Brain (1905), however, found setae sparingly produced on nutrient gelatine but appearing abundantly on sugar cane extract.

Fusarium moniliforme var. majus. This fungus grows well on agar media and on sterilized plant tissues. As a general rule, it

grows luxuriantly on media that contains dextrose. The aërial mycelium ranges from cottony white to pale Persian lilac, pale aniline lilac, cameo pink, and pale hortense violet. The submerged mycelium is slimy and ranges from lavender to hyssop violet and cinnamon buff.

The fungus produces sclerotia-like bodies consisting of dark masses of mycelium on oatmeal agar with two per cent dextrose. It also produces *pionnotes* and *sporodochia* on old cultures of potato plugs and potato-dextrose agar.

Rhizoctonia solani. This fungus produces fast-spreading mycelium on potato dextrose agar, oatmeal agar, corn meal agar, and on sterilized potato plugs and bean pods. The mycelium is grayish white at first, appearing dusty or chalky and subsequently turning brown to blackish brown with age. Very few sclerotial bodies are produced in culture.

TESTS OF PATHOGENICITY

Inoculation experiments using separately pure cultures of *Glomerella gossypii, Fusarium moniliforme* var. *majus,* and *Rhizoctonia solani* gave high percentages of infection.

Pure culture of *Glomerella gossypii* was applied on cotton seedlings of different ages, on squares, open-flowers, leaves, stems, and bolls of Batangas White cotton plants.

Rhizoctonia was applied either at the base of cotton seedlings of different ages or the culture of the fungus was mixed with sterilized soil in pots. Delinted cotton seeds were later planted in the soil.

With *Fusarium moniliforme* both methods (for *Glomerella* and *Rhizoctonia*) were employed.

In all cases infection was obtained readily and each fungus proved easy of reisolation. The results of the inoculation experiments may be summarized as follows:

Glomerella gossypii

1. The average percentages of infection were 100 per cent on seedlings 1 to 2 weeks old; 73.5 per cent on seedlings 3 weeks old; 100 per cent on squares; 78 per cent on open-flowers; and 100 per cent on cotton bolls.

2. As a rule, seedlings were readily attacked by the fungus before the first true leaves were produced.

3. Young seedlings, squares, and open-flowers were infected without wounds. Mature leaves, stems, and bolls were infected only through wounds.

4. The development of the fungus on cotton plants was markedly affected by the presence of moisture.

5. The anthracnose fungus took a longer time to infect and kill mature cotton plants than younger and more succulent ones.

Fusarium moniliforme var. majus

1. The average percentage of infection of seedlings just emerging was 60. Seedlings of cotton three-weeks old were not infected.

2. On flowers and bolls of different stages of development, infection through injuries was 100 per cent.

3. The fungus did not infect the leaves of the cotton plants when applied in the form of spray on the uninjured foliage.

4. As a rule, seedlings of cotton infected by the fungus showed the symptoms of the disease a week after the delinted seeds were planted in an inoculated sterilized soil.

5. The fungus infected the flowers and bolls of cotton more severely than any other parts of the plant.

6. The fungus is weakly parasitic. It affects primarily the flowers and bolls of cotton. If seeds of cotton for planting are taken from infected bolls and are planted without delinting, the seedlings are infected by the fungus that is borne on the lint.

Rhizoctonia solani

1. Cotton seeds planted in *Rhizoctonia*-infested soil germinated, but under humid conditions all the shoots died and rotted.

2. In the open and in the absence of frequent rains, however, good germination was obtained both in the *Rhizoctonia*-infested lot and in the control. Seventy five per cent of the seedlings in the inoculated lot and 85 per cent in the control emerged to the surface. Of those seedlings that came up in the inoculated lot 46.67 per cent was without any infection while 53.33 per cent showed infection. Only 37.5 per cent of these infected seedlings died, the others (62.5 per cent) recovered from the disease.

3. Inoculated cotton seedlings, 10 to 15 days old, were readily infected. Plants one and one-half months old or older seldom get the disease.

4. *Rhizoctonia* infection spreads very fast. The plants are either killed in a short time or they succeed in recovering and outgrowing the disease.

TAXONOMY

Glomerella gossypii (Southw.) Edger.

Edgerton (1909) first found the perithecial stage of the anthracnose fungus on cotton bolls in the field. This author transferred Southworth's *Colletotrichum gossypii* from the Moniliales of the Fungi Imperfecti to the Sphaeriales of the Ascomycetes. Edgerton (1909) found its ascigerous characteristics to agree very closely with those of the genus *Glomerella* of the Family Gnomoniaceae. For this reason he proposed the combination *Glomerella gossypii* (Southw.) Edger. (*Colletotrichum gossypii* Southw.) for the cotton anthracnose fungus.

The result of the writers' work on cotton anthracnose in the Philippines corroborates that of Welles (1921) who states that only the imperfect stage of *Glomerella gossypii* is produced by the fungus in the Philippine Islands.

Fusarium moniliforme var. majus

A sub-culture of the first isolation from cotton seedlings on December 28, 1934, was sent to Doctors H. W. Wollenweber and O. A. Reinking of the Biologische Reichsanstalt für Land- und Fortwirtschaft, Berlin-Dahlem, Germany. The fungus was identified as *Fusarium moniliforme* var. *majus*. This variety of *Fusarium moniliforme* was first described by Wollenweber and Reinking in 1925 from growths on fruit peduncles and dying leaves of banana collected from Honduras, Central America (Wollenweber and Reinking, 1925, 1927). Wollenweber's measurements and figures of the macroconidia and microconidia of *Fusarium moniliforme* var. *majus* are given in *Fusaria autographice delineata* No. 976 (1930). Studies made by the writers of all cultures of *Fusarium* isolated from cotton showed much resemblance to *Fusarium moniliforme* var. *majus*.

Rhizoctonia solani

Morphological and infection studies with the *Rhizoctonia* associated with soreshin show that the fungus is identical with the well-known cosmopolitan species, *R. solani*.

LIFE HISTORIES OF THE CAUSAL FUNGI IN RELATION TO PRODUCTION OF DISEASE

Seasonal occurrence in the field

Glomerella gossypii. In the College of Agriculture, the fungus becomes conspicuous on the bolls during the months of November, December, and January. During the months of May and June it is practically absent from the field.

Observations show that *Glomerella gossypii* attacks cotton in all stages of development. As infected seeds are the most important source of inoculum, anthracnose infection is common and serious on young seedlings. Infection of cotton is also common during the fruiting stage of the plant. At this time, the fungus attacks the bolls.

Insects, wind, and rain seem to spread the fungus easily in the field. The lumps of spores are dispersed when they come in contact with water. The conidia are also spread by man at harvest and planting time.

Inoculation experiments showed that the method of infection is often through wounds. Infection of the stem, leaves, and bolls takes place readily in the field through injuries caused by insects and other agents. Young stems, cotyledons, and flowers, however, are affected even if there are no visible injuries on them.

Fusarium moniliforme var. majus. The fungus at the College of Agriculture is not yet widespread and destructive. It occurs only in sporadic cases. These cases occur both in the wet and in the dry months. The infection of the bolls by *Fusarium* is prevalent when the cotton plants are fruiting during the rainy months.

Observations show that the fungus attacks the plant either when the seedlings are emerging through the soil, or when it is flowering and producing bolls.

Fusarium is one of the fungi whose spores are readily carried by air currents. This had been shown repeatedly in spore-catching experiments using sterile potato-dextrose agar in Petri dishes. The possibility of insects (*Dysdercus megalopygus* Breddin, *Tectocoris lineola* Fabricius and a species of *Camponotus* [3]), spreading the spores of this fungus has been shown experimentally in this work. It seems probable that dissemination of the spores by insects also takes place readily in the field.

Fusarium moniliforme var. *majus* infects cotton usually through wounds or mechanical injuries. Injury of the flowers and bolls by the fungus readily takes place when the parts are wounded or injured by insects and other agencies. Young cotton seedlings are readily affected by the fungus even though there appear to be no visible wounds at the base of the stems which are naturally very tender.

[3] The insects were identified by Dr. L. B. Uichanco, of the Department of Entomology, to whom the writers are indebted.

Rhizoctonia solani. This fungus grows actively from July to December. It attacks cotton seedlings severely, often killing them soon after infection. In addition to cotton the fungus also attacks many other plants, either cultivated or wild. The hyphae of the fungus spread very fast and penetrate the tender epidermis of young stems directly. Two-month-old cotton plants or older are slightly affected.

Methods of tiding over adverse conditions

Glomerella gossypii is carried within the seeds of cotton. In the seeds the mycelium remains alive for one or two years. Under laboratory conditions the spores of the fungus can also remain alive on infected cotton bolls, stems, and leaves from 8 to 9 months.

Fusarium moniliforme var. *majus* is carried on the lint of cotton seeds but not internally in the seed. It also lives saprophytically in the soil and in rotting infected cotton parts on the ground.

Rhizoctonia solani. Under conditions in the field the fungus produces sclerotial bodies. During adverse weather conditions these sclerotia remain alive in the dormant condition. The fungus may also be in the form of dormant mycelium in old infected cotton stems and other host plants.

In the College of Agriculture *Rhizoctonia solani* has been associated with the following plants:

1. African ground nut (*Voandezzia subterranea* Thou.)
2. Avocado (*Persea americana* Mill.)
3. Beans (*Phaseolus lunatus* L., *P. vulgaris* L., *Phaseolus aureus* Roxb.)
4. *Begonia* spp.
5. Calamismis (*Psophocarpus tetragonolobus* DC.)
6. Camote (*Ipomoea batatas* (L.) Poir)
7. *Canna* spp.
8. Citrus seedlings
9. Corn
10. Cowpea
11. Indigo (*Indigofera hendecaphylla* Jacq.)
12. Peanut
13. Rice
14. Rose
15. Soybean
16. Sugar cane
17. Teak seedlings (*Tectona grandis* L.)

Rhizoctonia solani is very common in the soil where it lives as a saprophyte. Under certain conditions it attacks plants and causes diseases. Blights, rots, wilt, and damping-off are some of the diseases commonly produced by this fungus. In addition to the plants listed above probably many others including weeds are also attacked under field conditions.

CONTROL MEASURES

1. *Seed selection.* Barre (1912) reports that he was able to obtain a crop free from anthracnose by selecting seeds from healthy plants in a field where 20 per cent of the bolls were infected. The crop from the unselected seeds from the same field was badly diseased.

The writers recommend that rigid selection of seeds of cotton while the plants are in the field should be done. Seeds should be taken only from plants free from diseases. Seed selection will considerably reduce infection with anthracnose and *Fusarium* diseases.

2. *Seed delinting.* Delinting cotton seeds with sulfuric acid was found to be a practical method of control for both anthracnose and *Fusarium.* The fungus *Fusarium moniliforme* var. *majus* is found only in the lint and does not penetrate the cotton seed. Ordinary delinting destroys the fungus from the lint which covers the seeds. In the case of the anthracnose, however, the causal organism is also carried in the seed internally. For this reason delinting the cotton seeds reduces anthracnose infection of the seedlings considerably but not entirely. In addition to destruction of superficially carried organisms on the seeds, delinting gives greater percentages of germination. Furthermore, the seedlings emerge through the soil faster than those from seeds not treated with concentrated sulfuric acid.

3. *Hot water treatment.* In 1910, Duggar and Cauthen (1911) found that the amount of seed-borne infection of cotton anthracnose could be reduced by immersing diseased seeds for 22 minutes in water at a temperature of 60°C. Barre and Aull (1914) found that cotton seed could be kept in water at 70°C. for 15 minutes without injury to germination, and diseased seed germinated free from disease. This method, however, requires great care, accuracy, and practice, so it cannot be recommended to farmers for their general use. Lehman (1925) states that this method offers certain difficulties. It appears that a temperature of less than 70°C. for 15 minutes is too low to destroy the seed-borne mycelium, while a temperature of more than 75°C. for 15 minutes causes considerable reduction of germination of seed treated. Barre (1915) states that some varieties

of cotton seeds are killed at 72°C., while others will tolerate 76°C. The close temperature limits for the killing of the seed and of the fungus make it difficult in practice to maintain the water at a proper temperature when seeds are treated in quantity. For this reason it does not appear that hot-water treatment can be depended upon for eradicating seed-borne anthracnose.

4. *Use of old seed for planting.* Barre (1916) states that three-year-old seeds kept in the laboratory gave disease-free plants when planted in the field. Some of the seeds claimed by farmers to be three years old and kept in sheds or barns, however, did not give satisfactory results. Ludwig (1925) states that the best treatment for infected seeds is to delint it with strong sulfuric acid, place it in clean bags, and store it two or three years in a dry building. He also reports that storing seed in a moist atmosphere causes rapid reduction of anthracnose infection, but the seeds quickly become musty. They fail to germinate. Storage in a dry atmosphere greatly prolongs the life of the fungus. The writers' observation, corroborated by Dr. Eulalio P. Baltazar, of the Department of Agronomy, is that cotton seeds kept in the laboratory under the climatic conditions of Los Baños, give scarcely 30 per cent germination after one year. The writers believe that aging cotton seeds for the control of anthracnose as recommended by investigators in the United States is not satisfactory under Los Baños climatic conditions.

5. *Dry heat.* Lehman (1925) reports that the effective treatment for the control of the disease without serious diminution of germination consists of 20 to 24 hours of desiccation at 60 to 65°C. followed by 12 hours of heating at 95 to 100°C. He further states that the moisture content of cotton seeds modifies their resistance to heat. When the moisture content of seeds was not greater than 3.62 per cent of the dry weight of the seed, no serious loss of viability resulted from the treatment at 95°C.

This method appears to be an effective measure for eradicating seed-borne anthracnose. Since it involves the use of a drier and thermometers, which farmers cannot readily obtain, however, it cannot be satisfactorily recommended outside of laboratory conditions in the Philippines.

6. *Control of the disease in the field.* With *Rhizoctonia* stem rot the most practical method of control would be to eliminate sources of infection from the field. Badly diseased cotton plants and other hosts should be pulled out with the parasite on them and burned completely.

SUMMARY

1. Anthracnose is the most prevalent and destructive disease of cotton in the Philippine Islands at the present time. *Fusarium* stem and boll rot and soreshin are not yet widespread, having been observed in the cotton plantings of the Departments of Agronomy and Plant Pathology only occasionally.

2. The cause of each disease has been determined as follows: *Glomerella gossypii* (South.) Edger. for anthracnose, *Fusarium moniliforme* Sheldon var. *majus* Wollenweber and Reinking for *Fusarium* stem and boll rot and *Rhizoctonia solani* Kühn for soreshin.

3. These fungi occur destructively during wet months but are practically unnoticeable during the hot dry months of the year.

4. *Glomerella gossypii* is carried on the lint and in the cotton seeds internally; *Fusarium moniliforme* var. *majus* is carried on the lint of cotton seeds and in the soil. *Rhizoctonia solani* lives in the soil in the form of sclerotial bodies or as dormant mycelium in infected cotton and many other plants.

5. Field selection of seeds is recommended for the control of anthracnose and the *Fusarium* disease of cotton. Delinting seeds with concentrated sulfuric acid before planting helps to reduce anthracnose infection considerably by destroying the fungus carried externally by cotton seeds. The treatment with concentrated sulfuric acid destroys all spores of *Fusarium moniliforme* var. *majus* on the lint and is a practical control for this fungus.

6. Collecting and burning diseased cotton and many other host plants of *Rhizoctonia solani* will help to reduce sources of infection. Transfer of sclerotial bodies with planting materials or compost to an uninfected locality should be guarded against.

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AN AGRONOMIC STUDY OF THE NATIVE AND THE HAWAII GINGERS [1]

PETRONILO B. ROSALES

WITH ONE CHART AND ONE TEXT FIGURE

In the Philippines very little attention has been given to the growing of ginger (*Zingiber officinale* Roscoe). It is only in recent years that farmers have begun to realize the importance of this crop.

This may be attributed to the increasing demand for this product in the last few years. According to Rivera (1930), there are several commercial concerns which can use Philippine ginger in the United States, Canada, and Australia. He states further that in the Philippines there are several aërated water factories and drug stores which import essence of ginger. According to this author, ginger is grown in nearly all parts of the Islands; but in Los Baños, Laguna, in Tanauan, Batangas, and in Silang, Cavite, it is more extensively cultivated than in other parts of the country.

As far as the writer knows, there are only two varieties of ginger under cultivation in the Islands—the so-called Native and the Hawaii. The native variety is grown in almost all parts of Batangas, but it is seldom grown on a large scale. In Los Baños and probably elsewhere in Laguna the Hawaii variety is very popular. The Native variety is seldom grown in this province except on a small scale for household use.

It is a common belief among local farmers that the Hawaii variety is better than the Native. There are no studies in the Philippines about these two varieties of ginger to support this belief. This work was undertaken to ascertain which of the two varieties is better.

Object of the present study

The object of this investigation was to study the agronomic characters of the Native and the Hawaii varieties of ginger involving the determination of (*a*) sprouting, (*b*) growth habits, (*c*) height

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and spread of the plants, (*d*) yield of the plants, (*e*) age at maturity, (*f*) storage qualities, and (*h*) susceptibility to pests and diseases.

Time and place of the present study

The work was performed under the Department of Agronomy, from June 15, 1933, to June 1, 1934. The culture of this experiment was carried on in the Experiment Station fields of the College of Agriculture and the storage was done in the storage room of the annual farm crops division of the Department of Agronomy. The chemical analysis was performed by the Department of Agricultural Chemistry.

MATERIALS AND METHODS

Planting materials

The planting materials of both the Native and the Hawaii varieties of ginger were secured from San Antonio, Los Baños, Laguna. One and one-half *caings* [2] (weighing 60 kgm.) of rhizomes of each variety were needed to plant the whole field used.

Preparation of the rhizomes for planting

Planting materials were prepared by cutting off with a knife any portion of the rhizomes which bore two to three apparently living "eyes". This was done three days before planting so the freshly cut wounds would partly heal up. The length of the sets or cuttings ranged from 3 to 6 centimeters for the Native variety, and 4 to 9 centimeters for the Hawaii.

The field and its preparation

The land used in this experiment covered an area of 800 square meters. It was plowed twice and harrowed once after each plowing. During the first plowing most of the weeds were gathered and piled on the border of the field. The land was then harrowed immediately to break up the big clods. After one week the land was plowed and harrowed again to expose and collect the weeds which were turned under the furrow slices at the first plowing, and also to pulverize the soil further. The collected weeds piled on the border of the field were burned.

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[2] *Caing* is a wide-mouthed basket made of either rattan or bamboo. This was used to measure the volume of the planting materials because it was the available unit of measure.

Plots

After preparing the land, ten plots for each variety were laid out. Each plot was 2 meters wide and 20 meters long. A path 30 centimeters wide was allowed between every two plots.

The soil in each plot was forked up and pulverized thoroughly before planting. A garden rake was used for leveling the plots.

Arrangement of plots and planting the sets

The cuttings were planted on June 26 and 27, 1933. Ten plots were planted to each variety which was planted in alternate plots. Before planting, furrows 10 cm. deep and 50 cm. apart were made with a grub hoe.

The sets were planted at a depth of about 10 centimeters and distanced 30 centimeters apart in the furrow. The sets were laid flat on the bottom of the furrow and were covered with fine soil particles with a trowel. Two hundred fifty-six cuttings of each variety were planted in each plot.

Weekly measurements of growth

When the plants were from 8 to 10 centimeters high, 50 plants of each variety were marked at random for growth measurement. These plants were measured weekly for fifteen weeks.

Cultivation and care

The field was continuously weeded with both hoe and trowel during the growing period of the plants. When the plants reached a height of about 20 centimeters, they were hilled up. This is a necessary operation in the culture of ginger because the tendency of the rhizomes is to grow upward.

The field was not touched after the first hilling-up except for an occasional weeding out in and between the rows of plants and the hilling up again a month after the first one.

Harvesting

The crop was harvested on January 22, 1934.

Harvesting was done when the leaves and stems had withered. A grub hoe was used for digging up the rhizomes. Great care was exercised while digging and handling the rhizomes to avoid damaging them because bruised, broken, and cut rhizomes lower the quality of the harvest. The soil between the branches of the rhizomes was cleaned out. The harvests from the different plots were weighed

separately and the corresponding volumes were measured in empty petroleum cans.[3] The weights and volumes obtained were recorded.

Storing

The harvested rhizomes were stored from January 27 to June 1, 1934. They were placed in different sacks and a wooden label was attached to each sack. Each label bore the variety name and the plot number. The mouths of the sacks were closed by tying with a wire. The sacks were then placed in one corner of the storage room where rain water could not reach them.

Frequent observations were made during the storing period until the sprouts appeared. From this time, observation was made weekly. The rhizomes were weighed when the sprouts first appeared on May 17, 1934, and at the end of the storing period, June 1, 1934. Observation was extended up to the time the rhizomes showed sign of much rotting.

EXPERIMENT AND RESULTS

Field observations

It was observed that the sets did not sprout at the same time. Sprouting was first noted with the Native ginger 18 days after planting, and with the Hawaii ginger, 19 days after. Of the 256 sets of each variety which were studied to determine the number of days each required to sprout, it was found that 255 sets of the Native ginger grew and 250 of the Hawaii. The last day of sprouting of the Native ginger was on the thirty-fifth day after planting and the Hawaii ginger on the forty-fifth day.

No serious insect pest was found attacking the plants in any stage of growth during the experiment.

The only disease which was found in the field was a leaf spot. This disease attacked only the mature leaves of both varieties of ginger and did not cause serious damage on ginger. Dr. G. O. Ocfemia, of the Department of Plant Pathology, diagnosed the disease and reported that it was caused by *Caniothyrium zingiberi* Stevens et Atienza. This disease was originally described by Stevens and Atienza (1931).

Observations on storage work

It was observed in both varieties that sprouting of stored rhizomes occurred about two weeks before the planting season of ginger

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[3] A petroleum can instead of a *caing* was used in measuring the volume of harvest to determine accurately the yields of each variety per plot. A petroleum can has a capacity of 20 liters.

in this locality. Sprouting started on May 17, 1934, and seemed to go on very rapidly in the Native variety. In the Hawaii ginger, however, sprouts were seen very sparingly and only in some of the sacks. The sprouts were just coming out when observed on May 24, 1934. This characteristic of ginger to sprout during the latter part of the storing period is important because it is a reliable indication of the viability of the rhizomes.

During the period of storage the Hawaii ginger was severely attacked by scale insects. They covered almost all the surface of the rhizomes. The Native variety showed very little infestation. Ants were found to attack some of the rhizomes of both varieties. A few rotted rhizomes in both varieties studied were also noted.

RESULTS AND DISCUSSION

The results of this study are presented in tables 1 to 11.

Comparison of varieties used

In table 1, it may be seen that the two varieties studied did not differ in color of the leaves, stem, and rhizomes and mode of branching of the rhizomes.

Length of time from planting to harvesting

It may be seen in table 2 that the Hawaii ginger required a longer time to mature than the Native. The Native ginger required on the average shorter time to sprout than the Hawaii. The probable error of the difference between the two means is very significant, the Native variety being the better as it required fewer days to sprout. Both varieties required practically the same number of days from planting to the time the leaves began to turn yellow. The probable error of the difference between the two means is insignificant. Withering of the leaves and stems continued for some days until almost all parts of the plant above the ground were dry. The plants were considered mature when they reached this last stage of withering. The probable error of the difference between these two means was found to be significant.

Sprouting (germination)

It was found that the Native variety of ginger gave a higher percentage of sprouting than the Hawaii variety, as may be seen in table 3. The probable error of the difference is significant.

Weekly growth

The probable error of the difference between these means of weekly growth is not significant. Both varieties had a rapid rate of growth during the first three weeks after germination. The rate of growth decreased gradually from the third week to the fifteenth week, except in the thirteenth week when the rate of growth abruptly increased following the increase of rainfall during that week. The rate of growth may be seen in table 4 and in chart 1. It may also be seen from the chart that, in general, there was no direct relation between the amount of rainfall and the rate of growth of ginger.

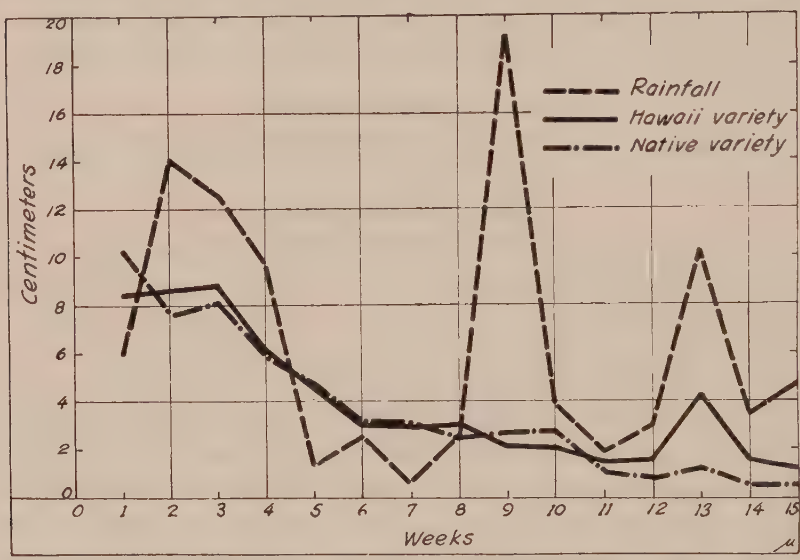

Chart 1.—Weekly rainfall and rates of growth of Hawaii and Native gingers

Chart I shows that the greatest amount of rainfall occurred during the ninth week, but the most rapid rate of growth of the Native variety was in the third week and of the Hawaii in the first week. The least amount of rainfall fell during the seventh week, but the slowest rate of growth of both varieties was during the fifteenth week.

Stand on the plots

In the plots the two varieties differed in the stand of the plants (table 5). The Native ginger had a better stand than the Hawaii. There were more missing hills in the plots of the Hawaii ginger than in those of the Native. The probable error of the difference is significant.

Yield

Yield of each variety per plot. The yield of the Hawaii variety was decidedly greater than that of the Native (table 6). It is safe to say that in this culture the yield of the Hawaii ginger was greater than that of the Native. The probable error of the difference between the mean weights of the two varieties is significant.

Yield of each variety per hectare. The computed yield of each variety per hectare is shown in table 7. Computation was made on the basis of 100 per cent stand. The probable error of the difference between the mean weights of the two varieties is very significant, the Hawaii ginger being the better.

Storage qualities

Of the two varieties the Native was found to have better storing qualities than the Hawaii (see tables 8, 9, and 10). The appearance of a higher percentage of sprouted rhizomes in the Native variety

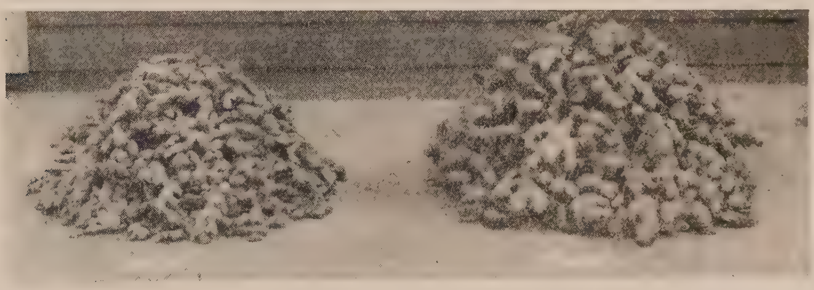

Fig. 1.—Showing the yield per plot and the difference in size of the individual rhizome of each variety of ginger, piled after harvesting

just before the planting season came is a disadvantage to the Native ginger as sprouted rhizomes seldom find a market. The Hawaii ginger, therefore, is better in this respect than the Native. If, on the other hand, the rhizomes are stored for planting purposes, the Native variety is better than the Hawaii ginger as the planter is certain of getting a high percentage of germination for he is planting rhizomes which have already started to grow.

The probable error of the difference between the means of sprouted rhizomes (table 8) was found to be very significant, the Native variety giving a higher percentage of sprouting.

The average loss in weight of the Native ginger from the date of storing to the time sprouts appeared, as shown in table 10, was 32.55 ± 0.53 per cent and the Hawaii ginger, 39.17 ± 0.41 per cent.

The average loss in volume of the Native variety during the same period was 22.35 ± 1.24 per cent and the Hawaii, 30.65 ± 0.83 per cent. During the storing period, that is, from January 27 to June 1, 1934, the average loss in weight of the Native ginger was 33.93 ± 0.58 per cent and the Hawaii, 41.33 ± 0.50 per cent; and the average loss in volume for the same period of the Native ginger was 25.8 ± 0.77 per cent and the Hawaii, 32.55 ± 0.70 per cent. These figures show that the loss in weight and in volume of both varieties was very much greater from the date of storing to the time sprouts appeared than from the time the sprouts appeared to the end of the storing period. The loss in weight and in volume of the Hawaii ginger was greater than that of the Native.

Proximate chemical analysis

The results of the chemical analysis of the tender parts of the rhizomes for the proximate constituents are shown in table 11.

SUMMARY AND CONCLUSIONS

1. The important characters of the Native and Hawaii varieties of ginger which were studied are yielding power, age at maturity, proximate chemical constituents of the tender parts of the rhizomes, sprouting, stand, rate of growth, and storage qualities.

2. The size of the leaves and rhizomes was larger in the Hawaii ginger than in the Native. On the whole, the plants of the Hawaii ginger were taller and the leaves more spreading than the Native.

3. The Hawaii ginger sprouted in 35.0 ± 0.23 days and the Native in 26.5 ± 0.02 days. The average germination of the Hawaii ginger was 95.24 ± 0.45 per cent and the Native, 97.74 ± 0.36 per cent.

4. The plants were mature when the leaves were completely dry. The Hawaii ginger reached maturity in 203.0 ± 0.40 days and the Native, in 199.6 ± 0.62 days.

5. The average stand of the plants of the Hawaii ginger was 94.47 ± 0.37 per cent and that of the Native, 96.88 ± 0.45 per cent.

6. The average weekly rate of growth for fifteen weeks of the Hawaii ginger was 3.96 ± 0.48 cm. and the Native, 3.63 ± 0.55 cm. Growth was most rapid during the first three weeks and slowest during the fifteenth week.

7. The percentage in weight of sprouted rhizomes at the end of the storing period was 60.3 ± 2.21 for the Native variety and 5.8 ± 1.48 for the Hawaii.

8. The loss in weight of the Hawaii ginger during the storing period was 41.33 ± 0.50 per cent and the Native, 33.93 ± 0.58 per cent.

9. The production of rhizomes per unit area of the Hawaii ginger was greater than that of the Native. The Hawaii ginger gave an average computed yield per hectare of 11,346.7 ± 314.79 kgm. and the Native, 7,853.25 ± 271.78 kgm.

10. The tender parts of the rhizomes of the Native ginger contained 84.16 per cent moisture, 0.91 per cent fats, 1.28 per cent ash, 1.38 per cent protein, 0.87 per cent crude fiber, and 11.40 per cent carbohydrates. The Hawaii ginger analyzed 86.63 per cent moisture, 0.55 per cent fats, 1.58 per cent ash, 0.82 per cent protein, 0.77 per cent crude fiber, and 8.67 per cent carbohydrates.

11. The Hawaii ginger contained 48.00 calories per 100 grams weight of rhizomes and the Native, 61.00 calories.

12. Neither of the two varieties was attacked by serious pests and diseases in the field.

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STEVENS, F. L., and JUAN D. ATIENZA. 1931. Diseases of cultivated ginger. The Philippine Agriculturist 20: 171–176. *Fig. 1–4.*

TABLE 1

Different agronomic characters studied of both varieties of ginger

CHARACTERS	NATIVE VARIETY	HAWAII VARIETY
Color of the young leaf	light green	light green
Color of the mature leaf	green	green
Color of the stem	green	green
Color of the base of the stem	whitish pink	whitish pink
Color of the rhizomes	cream	cream
Consistence of the corky layer of the rhizomes	firm	loose
Shape of each segment of the rhizomes	slender	globose
Form of the cross section of the rhizomes	oblong	circular
Constrictions between the segments of the rhizomes	shallow	deep
Branching of the rhizomes	lateral	lateral
Average height of the plants (cm.)	51.39 ± 0.52	59.9 ± 0.50
Average spread of the plants (cm.)	42.33 ± 0.35	50.20 ± 0.37
Average length of mature leaf (cm.)	25.48 ± 0.11	30.72 ± 0.18
Average width of mature leaf (cm.)	2.55 ± 0.01	3.05 ± 0.02
Average circumference of the rhizomes (cm.)	6.52 ± 0.06	10.78 ± 0.14
Average number of tillers	7.56 ± 0.24	7.06 ± 0.25

TABLE 2

Number of days from planting to sprouting, to the yellowing of the plants, and to the complete withering of the leaves and stems

PERIOD	NATIVE VARIETY	HAWAII VARIETY
	days	*days*
Number of days from planting to sprouting	26.5 ± 0.02	35.0 ± 0.23
Number of days from planting to the time yellowing occurred	179.5 ± 0.20	180.3 ± 0.25
Number of days from planting to the time leaves and stems withered	199.6 ± 0.62	203.0 ± 0.40

TABLE 3

Percentages of sprouting of each variety studied

PLOT NO.	NATIVE VARIETY			HAWAII VARIETY		
	Sets planted	Sets sprouted	Sprouting	Sets planted	Sets sprouted	Sprouting
	number	*number*	*per cent*	*number*	*number*	*per cent*
1	256	256	100.0	256	252	98.4
2	256	254	99.2	256	248	96.9
3	256	250	97.7	256	246	96.1
4	256	248	96.9	256	242	94.5
5	256	256	100.0	256	238	93.0
6	256	246	96.1	256	250	97.7
7	256	254	99.2	256	236	92.2
8	256	246	96.1	256	238	93.0
9	256	246	96.1	256	246	96.1
10	256	246	96.1	256	242	94.5
Average			97.74 ± 0.36			95.24 ± 0.45

TABLE 4

Average weekly growth of the Native and the Hawaii varieties of ginger

WEEKS	NATIVE VARIETY	HAWAII VARIETY
	cm.	*cm.*
1st	10.4	8.4
2nd	7.6	8.6
3rd	8.1	8.8
4th	5.8	6.1
5th	4.7	4.5
6th	3.1	3.0
7th	3.0	2.9
8th	2.4	3.0
9th	2.6	2.1
10th	2.7	2.1
11th	1.1	1.4
12th	0.8	1.5
13th	1.3	4.3
14th	0.5	1.5
15th	0.4	1.2
Average	3.63 ± 0.55	3.96 ± 0.48

TABLE 5

Percentages of stand on the plants in each plot at maturity

PLOT NO.	NATIVE VARIETY			HAWAII VARIETY		
	Hills planted	Hills harvested	Stand	Hills planted	Hills harvested	Stand
	number	*number*	*per cent*	*number*	*number*	*per cent*
1	256	254	99.2	256	246	96.1
2	256	254	99.2	256	240	93.8
3	256	250	97.7	256	246	96.1
4	256	246	96.1	256	240	93.8
5	256	256	100.0	256	238	93.0
6	256	236	92.2	256	248	96.9
7	256	252	98.4	256	236	92.2
8	256	240	93.8	256	236	92.2
9	256	246	96.1	256	246	96.1
10	256	246	96.1	256	242	94.5
Average			96.88 ± 0.45			94.47 ± 0.37

TABLE 6

Actual yield per plot of each variety

PLOT NO.	AREA OF PLOT	NATIVE VARIETY		HAWAII VARIETY	
		Weight	Volume	Weight	Volume
	sq. m.	*kgm.*	*cans*	*kgm.*	*cans*
1	40	44.0	5.2	42.6	4.5
2	40	33.0	3.8	38.8	4.4
3	40	28.2	3.2	39.2	4.2
4	40	26.6	2.6	34.4	3.8
5	40	27.8	2.8	41.6	4.2
6	40	29.0	3.4	38.6	4.0
7	40	27.4	3.1	46.0	4.8
8	40	26.0	2.8	45.8	4.6
9	40	30.2	3.3	52.6	5.6
10	40	32.2	3.8	49.0	5.0
Average		30.44 ± 1.88	3.4 ± 0.16	42.86 ± 1.17	4.51 ± 0.11

TABLE 7

Computed yield per hectare of each variety on the basis of 100 per cent stand

PLOT NO.	NATIVE VARIETY		HAWAII VARIETY	
	Weight	Volume	Weight	Volume
	kgm.	*cans*	*kgm.*	*cans*
1	11,087.5	1,310.0	11,082.0	1,170.0
2	8,317.5	957.5	10,340.0	1,172.5
3	7,242.5	820.0	10,197.5	1,092.5
4	6,920.0	677.5	9,167.5	1,012.5
5	6,950.0	700.0	11,182.5	1,130.0
6	7,862.5	922.5	9,957.5	1,032.5
7	6,987.5	787.5	12,472.5	1,302.5
8	6,930.0	747.5	12,422.5	1,247.5
9	7,857.5	857.5	13,682.5	1,457.5
10	8,377.5	987.5	12,962.5	1,322.5
Average	7,853.25±271.78	876.75±39.45	11,346.7±314.79	1,194.0±29.75

TABLE 8

Weights of the rhizomes with and without sprouts at the end of the storing period

PLOT NO.	NATIVE VARIETY			HAWAII VARIETY		
	Weight of the sprouted and non-sprouted rhizomes	Weight of sprouted rhizomes		Weight of the sprouted and non-sprouted rhizomes	Weight of sprouted rhizomes	
	kgm.	*kgm.*	*per cent*	*kgm.*	*kgm.*	*per cent*
1	28.4	16.8	59	25.2	0.0	0.0
2	21.4	13.2	62	23.0	0.0	0.0
3	18.2	12.4	68	22.4	0.0	0.0
4	18.2	11.0	60	21.0	3.6	17
5	16.8	7.0	42	25.8	4.4	17
6	19.2	9.6	50	22.4	1.8	8
7	18.6	13.8	74	25.2	0.0	0
8	17.0	9.0	73	27.0	0.0	0
9	20.8	15.6	75	31.6	2.2	7
10	22.4	13.4	60	28.8	2.6	9
Average	20.1	12.18	60.3±2.21	25.24	1.46	5.8±1.48

TABLE 9

Weight and volume taken at two different times during the storing period

PLOT NO.	WHEN SPROUTS BEGAN TO APPEAR				AT THE END OF THE STORING PERIOD			
	Native variety		Hawaii variety		Native variety		Hawaii variety	
	Weight	Volume	Weight	Volume	Weight	Volume	Weight	Volume
	kgm.	*cans*	*kgm.*	*cans*	*kgm.*	*cans*	*kgm.*	*cans*
1	29.4	3.8	26.4	3.4	28.4	3.6	25.2	3.2
2	21.4	3.0	24.0	2.7	21.4	2.8	23.0	2.7
3	18.8	2.4	22.8	3.0	18.2	2.4	22.4	2.8
4	18.4	2.2	21.6	2.6	18.2	2.0	21.0	2.6
5	17.4	2.2	26.4	3.0	16.8	2.2	25.8	3.0
6	19.6	2.4	23.4	2.8	19.2	2.4	22.4	2.7
7	19.0	2.6	26.4	3.0	18.6	2.4	25.2	3.0
8	17.0	2.2	27.8	3.2	17.0	2.2	27.0	3.2
9	21.6	2.8	32.0	4.2	20.8	2.6	31.6	3.8
10	22.4	2.6	29.6	3.4	22.4	2.4	28.8	3.4
Average	20.5 ± 0.77	2.62 ± 0.11	26.04 ± 1.02	3.13 ± 0.10	20.1 ± 0.45	2.5 ± 0.02	25.24 ± 0.70	3.04 ± 0.02

TABLE 10

Shrinkage of the rhizomes in weight and in volume from the date of storing to the time sprouts began to appear and during the storing period

PLOT NO.	LOSS FROM THE DATE OF STORING TO THE TIME SPROUTS APPEARED								LOSS DURING THE STORING PERIOD							
	Native variety				Hawaii variety				Native variety				Hawaii variety			
	Weight	Per cent	Volume	Per cent	Weight	Per cent	Volume	Per cent	Weight	Per cent	Volume	Per cent	Weight	Per cent	Volume	Per cent
	kgm.		*cans*		*kgm.*		*cans*		*kgm.*		*cans*		*kgm.*		*cans*	
1	14.6	33.2	1.4	26.9	16.2	38.0	1.1	24.4	15.6	35.5	1.6	30.8	17.4	40.8	1.3	28.9
2	11.6	35.2	0.8	21.1	14.8	38.1	1.7	38.6	11.6	35.2	1.0	26.3	15.8	40.7	1.7	38.6
3	9.4	33.3	0.8	25.0	16.4	41.8	1.2	28.5	10.0	35.5	0.8	25.0	16.8	42.9	1.4	33.3
4	7.8	29.3	0.4	15.4	12.8	37.2	1.2	31.6	8.4	31.6	0.6	23.1	13.4	39.0	1.2	31.6
5	10.4	37.4	0.6	21.4	15.2	36.5	1.2	28.5	11.0	39.5	0.6	21.4	15.8	38.0	1.2	28.6
6	9.4	32.4	1.0	29.4	15.2	39.4	1.2	30.0	9.8	33.8	1.0	29.4	16.2	44.8	1.3	32.5
7	8.4	30.7	0.5	16.1	19.6	42.6	1.8	37.5	8.8	32.1	0.7	22.6	20.8	45.2	1.8	37.5
8	9.0	34.6	0.6	21.4	18.0	39.3	1.4	30.4	9.0	34.6	0.6	21.4	18.8	41.0	1.4	30.4
9	8.6	28.5	0.5	15.2	20.6	39.2	1.4	25.0	9.4	31.1	0.7	21.2	21.0	39.9	1.8	32.1
10	9.8	30.4	1.2	31.6	19.4	39.6	1.6	32.0	9.8	30.4	1.4	36.8	20.2	41.2	1.6	32.0
Average ..	9.9	32.55 ± 0.53	0.78	22.35 ± 1.24	16.8	39.17 ± 0.41	1.38	30.65 ± 0.83	10.34	33.93 ± 0.58	0.9	25.8 ± 0.77	17.62	41.33 ± 0.50	1.47	32.55 ± 0.70

TABLE 11

Proximate chemical analysis of the tender parts of the rhizomes [a]

CONSTITUENTS	NATIVE VARIETY	HAWAII VARIETY
	per cent	*per cent*
Moisture	84.16	86.63
Fats	0.91	0.55
Ash	1.28	1.56
Protein	1.38	0.82
Crude fiber	0.87	0.77
Carbohydrates (N.F.E.)	11.40	9.67
Total	100.00	100.00
Calories per 100 grams	61.00	48.00

[a] Analyzed by the Department of Agricultural Chemistry

NOTE: A METHOD OF ADDING ALKALI IN KJELDAHL DISTILLATION [1]

LAURO A. YNALVEZ
Of the Department of Agricultural Chemistry

WITH ONE TEXT FIGURE

Our experience in this laboratory has shown that the ordinary method of adding saturated alkali is not satisfactory. It often entails waste of chemicals and loss of time in the distilling operation. In the ordinary Kjeldahl procedure difficulty is met in regulating the amount of excess alkali; hence, very often, a very strongly alkaline solution results. Consequently, alkali is wasted. When many samples have to be analyzed for nitrogen, much sodium hydroxide is wasted. Likewise, when there is much excess alkali, frothing occurs. And when there is frothing, distillation takes longer time and needs more attention, as the froth very often passes over with the distillate into the receiver. Moreover, when the alkali added is not enough to make the solution sufficiently alkaline, loss of time is also entailed as additional alkali cannot be introduced without previous cooling. Recently, Miller (1936) observed a loss of 1.26 per cent ammonia in the usual Kjeldahl distillation process.

Hence, an apparatus that will minimize waste of chemicals and loss of time and will require the minimum attention in the distilling operation is very much needed. The apparatus here reported was devised, and a method of adding the saturated alkali to the Kjeldahl flask was evolved. This method is giving satisfactory results. The set-up embodies the recent improvements made in the ammonia-distillation system by Adriano (1932), Villanueva (1933), and Miller (1936).

The apparatus in detail is shown in figure 1. The boiler A as a source of steam, the Kjeldahl flask B, and the receiver C are connected in the usual way.

METHOD

The alkali is added as follows: First the solution of digested sample in Kjeldahl flask B is steamed for about five minutes to drive away the air in the system. Then screwcock S is opened and

[1] Experiment Station contribution No. 1211.

the alkali in funnel tube F flows down to Kjeldahl flask B. To avoid a violent reaction in Kjeldahl flask B, the flow of the alkali is made no faster than its rate of dissolution. Since the steam automatically stirs the solution and since the solution is hot, the reaction between

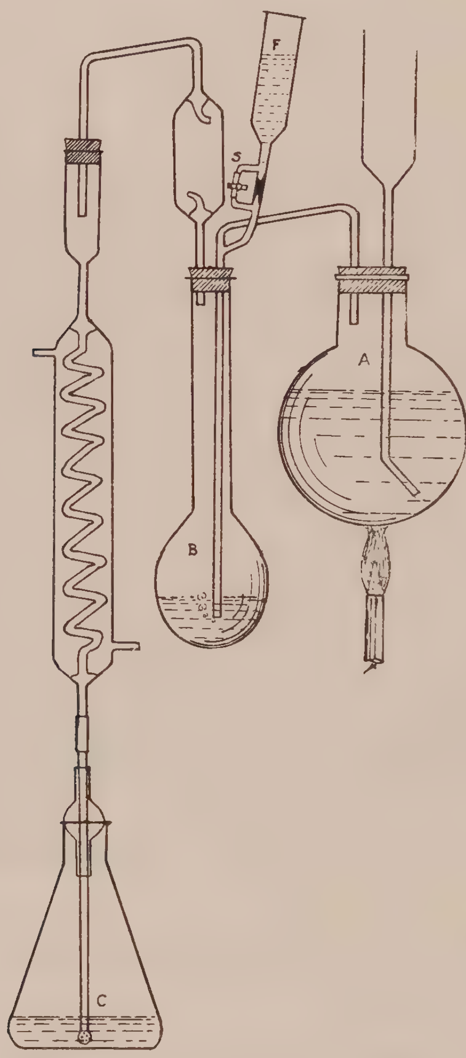

Fig. 1.—Set-up of Kjeldahl distillation apparatus showing accessory for adding alkali

acid and alkali is very fast. When the color of the solution has turned greenish, the flow of the alkali is made slow by gradually closing screwcock S. As the color of the solution turns gray, the

alkali is added drop by drop. When the color of the solution has become completely black, the addition of alkali is stopped by closing screwcock S. Then distillation is continued as usual until 300 ml. distillate is collected in the receiver.

The amount of excess alkali in the solution in the present method as compared with that in the usual method is shown in table 1. It is shown that there is less excess alkali in the solution in the present method than that in the usual method.

The advantages of the present method are summarized as follows:

1. The excess of alkali in the mixture is minimized because the addition of the saturated alkali can be regulated by closing and opening screwcock S. The average alkalinity of the solution after distillation in the usual method and in the present method expressed as per cent sodium hydroxide is 2.30 and 0.38 per cent respectively. The average alkalinity of the solution expressed as grams sodium hydroxide calculated on 400 ml. as total volume of the mixture after distillation is 9.20 grams in the usual method and 1.53 grams in the present method. The difference is 7.67 grams.

2. Frothing due to much excess alkali in the solution is reduced to the minimum.

3. The air in the system can be driven away by steaming the Kjeldahl flask containing the digested sample before the alkali is added. The air in the system is ascribed to by Miller as the cause of the loss of ammonia in the usual Kjeldahl distillation procedure. He believes that the ammonia during the first few minutes of distillation is diluted with air to such an extent that part of it escapes absorption by the standard acid through which it passes; whereas Adriano (1932) and Villanueva (1933) believe that the ammonia escapes while the alkali is being added.

A study is in progress in this laboratory to determine the influence of the concentration of the alkali in the mixture upon the length of time of distillation and the recovery of ammonia.

LITERATURE CITED

ADRIANO, F. T. 1932. Notes on the improved device for adding the saturated alkali solution in the Kjeldahl method of nitrogen determination. Natural and Applied Science Bulletin 2: 27–32.

VILLANUEVA, L. J. 1933. Modified ammonia bulb. Natural and Applied Science Bulletin 3: 451–452.

MILLER, H. S. 1936. A source of loss of ammonia in Kjeldahl distillations. Method of eliminating this loss. Industrial Engineering Chemistry. Anal. Ed. 8: 50–51.

TABLE 1

Showing the alkalinity of the mixture after distillation

USUAL METHOD OF ADDING ALKALI[1]		
Ml. taken from mixture	Ml. of standard H_2SO_4—.1493 N	Alkalinity (per cent NaOH)
10	38.3	2.29
10	38.5	2.30
10	38.5	2.30
Ave.		2.30

PROPOSED METHOD OF ADDING ALKALI[2]		
Ml. taken from mixture	Ml. of standard H_2SO_4—.1493 N	Alkalinity (per cent NaOH)
10	7.8	0.466
10	8.0	0.478
10	4.9	0.293
10	5.9	0.352
10	7.6	0.454
10	5.7	0.340
10	4.7	0.281
10	6.6	0.394
10	4.5	0.269
10	4.9	0.293
10	5.8	0.346
10	6.6	0.394
10	4.7	0.281
10	7.6	0.453
10	5.7	0.340
10	6.7	0.400
10	6.8	0.406
10	5.6	0.334
10	4.6	0.275
10	8.1	0.484
10	4.9	0.293
10	7.7	0.460
10	7.2	0.430
10	7.1	0.424
10	5.1	0.305
Average		0.383

[1] The aliquot is taken from 80-liter collection

[2] The aliquot is taken from individual determination

COLLEGE AND ALUMNI NOTES

The following faculty members were convocation speakers at the Pampanga Agricultural High School: Dr. Dionisio I. Aquino on December 4 and Dean B. M. Gonzalez on December 11.

The following papers were read at the Los Baños Biological Club on December 15:

Dr. José M. Capinpin. A lethal-linked kernel variation in Lagkit corn.

Mr. Mamerto D. Sulit. Notes on some poisonous plants in the Maquiling National Park and vicinity.

Dr. Tyozaburo Tanaka, professor of horticulture, Taihoku Imperial University, arrived on January 7 to serve as exchange professor in the University of the Philippines, where he will deliver a series of lectures in the College of Agriculture.

Dean and Mrs. B. M. Gonzalez were hosts to the College community at a New Year party in Molawin Hall. Feature numbers included rigodon de honor, bailes de ayer (prize-winning number), pas de quatre, lanceros, and "big apple."

The local Boy Scouts troop presented a musicale entitled "Living Patriotism" on November 24. The gate receipts were contributed toward the funds for the erection of a Boy Scouts Headquarters in Manila.

The students of the Rural High School presented Oliver Price's dramatization of Longfellow's "Evangeline" on December 3.

The pupils of the Maquiling School staged in the evening of December 17 a Christmas play entitled "In Fairyland."

The Maquiling Ladies Club were hosts at a Christmas party for the children of faculty, employees, and laborers of the College in the afternoon of December 23. Gifts were distributed to some three hundred children.

Mr. Eulogio Rodriguez, Jr., '25, was elected provincial governor of Rizal in the Philippine general elections of December 14, 1937. To Mr. Rodriguez belongs the distinction of being the first alumnus of this College to make the grade in politics.

Dr. Eduardo Quisumbing, '18, chief of the National Museum Division, Bureau of Science, sailed for Singapore on January 20 as a delegate to the International Congress of Prehistory.

Mr. José A. Serrano, '27, formerly in the office of the business manager, *The Philippine Agriculturist*, is at present a teacher in Upi Agricultural High School, Cotabato. Two other alumni now in the same school are Mr. Domingo Anioay, '32, and Mr. Teodoro Malasig, '38.

Mr. Zosimo T. Montemayor, '24, formerly principal of the Pili Agricultural High School in Camarines Sur, is now principal of the Pampanga Agricultural High School at Magalang.

Mr. Lorenzo L. Goco, '21, formerly of Agusan, is now stationed in Cavite as industrial supervisor.

Mr. Felix M. Esguerra, '22, resigned his position in the Bureau of Education to become agricultural supervisor of the Bureau of Plant Industry in Cotabato.

Mr. Ambrosio P. Cacayan, '36, formerly of the Hacienda Casalagan, Occidental Negros, has recently joined the malaria control section, Bureau of Health. His present station is at Angadanan, Isabela.

The Dean's Cup, donated by Dean B. M. Gonzalez, is at present held by the Lowland Tennis Club after it defeated the Faculty Hill Sporting Club at the annual tennis tournament on December 3.

The organization of the R.O.T.C. unit of the College of Agriculture and the School of Forestry held a military hop on November 27.

A NATIONAL RESPONSIBILITY

In an address delivered some three years ago at the third Philippine Science Convention by a leading American botanist,[1] a forceful thesis is presented in which productivity of a nation in the natural sciences is used as an index to political competence. After reviewing the parallel records of various countries as illustrative material, the author concludes in part:

> "Just as a strong and vigorous nation may welcome commercial relations with all comers, secure in its mastery of the situation, so may strong nations welcome scientific and other intellectual contacts. Whatever outsiders may do merely adds to what is done. It may give a new point of view, which is soon taken advantage of, so that the result is merely a greater uniformity of method among all nations that advance science and learning. Science is the common possession of all, and after scientific research is done it ceases to be of unique benefit to the individual, the institution, or the country that does it. But a curious fact is that research is never fully understood or utilized except by one who has trained himself to do it. Non-producers do not often have the capacity for intelligent borrowing."

Then he goes on:

> "The Philippines have the help and example of an American scientific and educational organization placed here at the beginning of the American occupation. Strong institutions were established, excellent scientific work was done, and the results have been published, to the great enhancement of Philippine prestige. The Philippine Journal of Science is favorably known everywhere. Other publications have been equally creditable. With the gradual placing of all Philippine affairs in native hands, the Filipinos have had the immense advantage of taking over what business men call a going concern. Whether it will keep going or not is the question people are asking everywhere. Perhaps out of politeness they do not often ask it in the presence of Filipinos, but it is asked in Java by Dutchmen, in the Malay States and India by Englishmen, by alert Japanese and Chinese wherever they may be. Americans ask it too, and are of two opinions as to the answer, but regardless of which opinion they hold they all hope that the Philippines may succeed.
>
> "The experiment of one nation deliberately preparing another for independence has never been tried before, and we believe it has succeeded. If scientists in general accept the validity of correlation I have attempted to

[1] BARTLETT, HARLEY HARRIS. 1937. Nationalism, imperialism, and spheres of influence in natural sciences. Proceedings of the Third Philippine Science Convention, February 26 to March 2, 1935. Nat. Res. Council (P. I.) Bull. 12: 75–97.

establish, between scientific aggressiveness and political competence, then the performance of the Philippine National Research Council, the Philippine Bureau of Science, and the University of the Philippines will be eagerly watched during the coming years by all who are interested in the experiment."

The foregoing passages are quoted at length in view of the important bearing they have on our current problems. Quite independently of the sentiments contained in this address, the convention which drafted the Constitution of the Philippine Commonwealth included the following as part of article XIII, section 4: "The State shall promote scientific research and invention." Recent developments have served to demonstrate the sincerity and earnestness of purpose of the men at the helm of the Philippine government when substantial appropriations were allotted the University of the Philippines and the various executive departments for the purpose of financing scientific research activities. Definite steps have been undertaken to realign the different research organizations of the government, not the least important being the plan to consolidate all its agricultural investigational programs into a National Agricultural Experiment Station, in order to promote greater efficiency.

We have neither cause nor desire to belittle the work of early American workers who made such institutions as the Bureau of Science and the University of the Philippines a "going concern." For them we have nothing but gratitude. In the interest of truth, however, it must be pointed out that these scientific institutions have always been Philippine, and not American, institutions. They have been supported by Philippine public funds and manned from the beginning to a greater or less extent by Filipinos. In the earlier stages of their organization and development, the directors and chiefs of divisions, as well as many of the ranking scientists, were nearly all Americans for the reason that there was not at the time an adequate supply of qualified local material. This initial gap was the result of want of opportunity, rather than inherent lack of capacity, for scientific work on the part of the Filipinos. What little scientific progress there was during the Spanish régime was certainly attained in spite, rather than because, of the prevailing spirit of that period. Moreover, it appeared that responsible participation by Filipinos in scientific work was discouraged, as witness the case of a native chemist, cited by Rizal: A competitive examination was given to fill the coveted post of director of the municipal laboratory in Manila. The chemist in question won with a brilliant score over his competitors, who were all Spaniards. Rather than award the

post to a native, the chair was abolished. Even the earlier American workers, with, of course, notable exceptions, did surprisingly little to encourage Filipino collaborators except to engage them as laboratory technicians.

The service that America has done in the way of promoting science in the Philippines is patent and beyond dispute. It would not be strictly accurate to assume, however, that America brought into this country, as through some magical process of blood transfusion, the last word in science and a body of finished American scientists. What America introduced, which neither Spain nor the Philippines possessed at the time, was her liberal, uninhibited attitude toward scientific questions. The fact can hardly be disputed that at the turn of the twentieth century, when American sovereignty was established in this country, America was as yet struggling to reach adolescent stage in her scientific life. In many ways she was still dependent on European guidance and inspiration. While the Philippines, therefore, was undergoing transformation under American rule, America herself was in the lush flowering of her youth and was attaining ripeness at least in part through the influence of her Philippine ward. Many an American college graduate came to the Philippines in the adventurous age of his early twenties, learned from the country, and enriched his experience through contact with an alien people, to return later to his homeland as a recognized authority in his line of activity.

THE ELON-RAM RICE [1]

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WITH TWO TEXT FIGURES

In the Philippines, two widely grown commercial rice varieties which are gaining more and more recognition from the rice farmers in the irrigated districts are Elon-elon and Ramai. Elon-elon is an important export variety. It produces polished rice which is classified in the market as "superior". It is in great demand and commands a high price on account of its good eating and superior milling qualities. Ramai is an imported variety, and since its introduction, it has excelled the other lowland varieties of the Philippines in yield. Its eating quality, however, is poor; but because of its high yield, it is considered "a rice for the masses whose chief consideration is quantity rather than quality."

From the standpoint of rice improvement, these two varieties possess attributes which are very desirable to combine, namely, the superior table and milling qualities and upright growth of Elon-elon, and the high yield of Ramai. The production of new varieties of rice which possess these commercial and agronomic characteristics is one of the phases of the work of the College of Agriculture for improving the rice industry. The present paper is a brief account of an attempt to produce a desirable rice hybrid and of the performance of the hybrid produced.

MATERIALS AND METHODS

Elon-elon and Ramai varieties were utilized as parents. The plants were grown in can cultures. On December 18, 1931, the author emasculated a few flowers of Elon-elon by clipping a part of the glumes and gradually removing the stamens with a pair of fine forceps. The stigmas of these emasculated flowers were then dusted with pollen obtained from Ramai plants, which were then in flower. The treated flowers were left unbagged and allowed to mature. At maturity only two grains which were definitely the products of cross-

[1] A revision of a paper read by the author before the Fourth Philippine Science Convention, Manila, Feb. 23–27, 1937. Experiment Station contribution No. 1212.

pollination developed. These were harvested on January 20, 1932. They served as the foundation seed material of the new rice, now called the Elon-ram.

EXPERIMENTS AND RESULTS

First generation. These two grains were planted separately in soil contained in petroleum cans, each of which was almost three-fourths filled on January 27, 1932. The plants that grew from one of the grains flowered on December 14, 1932, and the plants that arose from the other grain on December 27, 1932. Each grain produced four culms. The plants that flowered on December 14 were harvested on January 15, 1933, and the plants that flowered on December 27 were harvested on January 27, 1933. These two first generation hybrid rice plants differed distinctly from the parents and from each other in shape, size, and color of grains. Since they matured on different days, one was labelled early maturing and the other, late maturing. The earlier maturing hybrid plant possessed short grains, which were similar to those of Ramai, but which were light straw in color. The plants of the late maturing hybrid were heavy stoolers with long and compact panicles and long grains, but were of deeper straw color. Mature panicles from both hybrids were selected and saved for planting in the 1933-1934 season.

Second generation. During the 1933-1934 rice season, the grains of three panicles from each of the two strains were planted head-to-row in the field at the rate of one plant to the hill so as to obtain a fairly large number of individuals for selection purposes.

As might be expected, this second generation hybrid crop showed a mixture of types. The early maturing hybrid of the Ramai type produced some plants of the same type, which however, matured seven days later, and others of the same type, which matured very late. From the culture of the late maturing strain, two types, both resembling Elon-elon in shape of grains, were observed: namely, early maturing individuals with short panicles but longer sized and with plumper grains than the Elon-elon and late maturing plants with longer and fatter grains in much longer panicles than the earlier type.

About ten hills of this late type of the late-maturing strain, which from all appearances would have been high yielders, were stolen before harvest. At harvest time seed plants representing the different types were selected and labelled according to their type. The different types were named: early maturing strain of the Elon-elon type, or strain No. 1; late maturing strain of the Elon-elon type, or

strain No. 2; early maturing strain of the Ramai type, or strain No. 3; medium late maturing strain of the Ramai type, or strain No. 4; and late maturing strain of the Ramai type, or strain No. 5. Strain No. 2 proved to be the highest yielder in the 1933-1934 rice season. Moreover, it gave the highest percentage of uniformity in time of blooming, as will be seen in table 1. A few grains of this year's harvest of strain No. 2 were given for trial and further study in the Bureau of Plant Industry, to Mr. Victorino Borja, the rice agronomist of the bureau who was then enrolled as a student in this College. Also, one ganta of seed of the same strain was given to Mr. Senen Gabaldon, of Quezon, Nueva Ecija, for planting and another ganta to Mr. Antonio Alberto, of Cabuyao, Laguna, for culture in Cabuyao.

Third generation. From the crop of the 1933-34 culture, a few panicles reserved for head-to-the-row test of the different strains were planted in the following rice season (1934-35). The result of this head-to-the-row test may be seen in table 1.

The remainder of the seed was planted in multiplication plots. This planting was much larger than the previous ones, and it gave the following yield of seed palay: strain No. 1, two gantas; strain No. 2, four cavans and twenty gantas; strain No. 3, one-half ganta; strain No. 4, two and one-half gantas; and strain No. 5, three gantas. As in the previous crops, the plants of strain No. 2 in the head-to-the-row tests, as well as in the multiplication plot, flowered uniformly.

The plants from strain No. 2 during the 1934-35 crop were characterized by long, large panicles, heavy tillering, and long, large grains, as may be seen in figures 1 and 2.

The crop attracted the attention of neighboring farmers around the College farm. Some of the College tenants who had seen the crop volunteered to grow this hybrid rather than Elon-elon or Ramai.

As previously stated, some seed of strain No. 2 of the 1933-34 harvest was given to Mr. Gabaldon and Mr. Alberto, who planted them in the 1934-1935 season. Of this planting Mr. Gabaldon reported that he produced 7.2 cavans from one ganta of Elon-ram seed given to him for trial the preceeding year. The Elon-ram bloomed uniformly in Mr. Gabaldon's farm as observed by the Agronomy 13 students who visited the culture in December, 1935. Mr. Hugo Kasamata, an overseer on Mr. Alberto's farm in Cabuyao, Laguna, says that, from one ganta of Elon-ram seed palay, 4.5 cavans were obtained. He further reported that the plants bloomed very uniformly and were free from any pest or disease.

From the 1934-35 harvest, seed was given to the following persons for trial: One ganta to Mr. W. Dionido, of Naic, Cavite, one ganta to Mr. A. Manalo, of Cabanatuan, Nueva Ecija, and one ganta to Mr. F. Pineda, of San José, Nueva Ecija.

Fourth generation. Panicles were selected from each of the five strains planted head-to-the-row in the 1934-35 rice season and a portion of the seed taken from them were as usual planted head-to-the-row in 1935-36. The results of observation on uniformity in blooming in this particular planting are shown in table 1.

Fig. 1.—The Elon-ram (strain No. 2) F_3, and its parents. Note the heavy tillering power of the Elon-ram.

All available seed from non-selected panicles of 1934-35 harvest of strain No. 2 was planted in the 1935-36 rice season. The actual yield obtained in this planting was 91 cavans per hectare compared with an average yield per hectare of 57 cavans for Elon-elon and 65 cavans per hectare for Ramai, both varieties having been grown under similar conditions where the hybrid was grown, that is, in comparative cultures in the same year. This hectare-lot harvest showed that

Elon-ram (strain No. 2) excelled the higher yielding parent (Ramai) by 40 per cent and the lower yielding parent (Elon-elon) by 60 per cent in production of seed palay.

The following were the reports on the results of outside plantings: At the close of the harvest of the 1935-36 rice season Mr. Dionido stated that, from a portion of his field from which he usually obtained a yield of from 25 to 30 cavans per cavan of Inadhica seed palay, or 1 to 1.2 cavans per ganta, he obtained 6.52 cavans of clean

Fig. 2.—Panicles of the Elon-ram (strain No. 2) F_3, and its parents. Note the extra large panicles of the Elon-ram.

seed of strain No. 2 of Elon-ram seed palay from one ganta of seed planted. Mr. Manalo claimed that he obtained 6.18 cavans from the one ganta of seed he planted and that his plants bloomed and matured uniformly. Mr. Pineda reported a yield of 5.59 cavans from the one ganta of Elon-ram seed palay the College furnished him. These coöperators wrote that they would test the hybrid on commercial planting the following year (1936-37). Their results in the 1936-37 harvest are reported elsewhere in this paper.

The other four strains were not tested on hectare basis, but, in addition to the head-to-the-row planting of these strains, one-half ganta of seed of each was planted in the same season as strain No. 2 so as to keep in readiness seeds of these strains for further study. From one-half ganta of strain No. 1, twenty-seven gantas of seed palay were produced; from one-half ganta of strain No. 3, thirty-one gantas; from one-half of strain No. 4, thirty-two gantas; and from one-half ganta of strain No. 5, forty-two gantas.

Rice growers who heard of or actually saw the desirable field characteristics of College Elon-ram requested seed, but, because it was limited in amount, only the earlier applicants were supplied. The others, from whom requests were received later, were advised to wait for the 1936-37 harvest.

The College harvest of 91 cavans from the 1935-36 planting was allocated as follows: 24 cavans to the College; 20 cavans to Mexico, Pampanga; 15 cavans to Guimba, Nueva Ecija; 8 cavans to Cabiao, Nueva Ecija; 5 cavans to Cavite; 2 cavans to Negros; and 3 cavans to Baliuag, Bulacan.

Fifth generation. As in the previous generations, the grains of the selected panicles of each of the five strains were planted head-to-the-row at the rate of one plant to the hill in the 1936-37 rice season. In this season a greater number of plants were studied in each strain. In strain No. 1, for example, 2,400 plants were grown to maturity and were carefully studied as to time of flowering; 5,700 plants in strain No. 2; 300 plants in strain No. 3; 4,100 plants in strain No. 4; and 3,100 plants in strain No. 5. The percentage of uniformity in flowering was higher than in previous years, that of strain No. 2 again being the highest, 98.2 per cent (see table 1).

About four cavans of Elon-ram seed were planted in the College Experiment Station in August, 1936. The seeds were distributed to three different people for planting: one-half cavan to a research student who determined the comparative yields of Elon-elon, Ramai, and Elon-ram; one-half cavan each to 30 students taking a course in rice, who planted the Elon-ram seedlings in 30 plots of 200 square meters each; and three cavans to eight College aparceros who planted the seeds in the College lowland fields.

The research student obtained an average yield of 79.7 cavans per hectare from the Ramai, 67.1 cavans from the Elon-elon, and 100.3 cavans from the Elon-ram. The 30 students obtained a yield ranging from 2.05 to 3.27 cavans per plot of 200 square meters, or

an average computed yield of 133.0 cavans per hectare from the Elon-ram. The College aparceros obtained a yield of 90.7 cavans per hectare from it.

From random samplings made in the College of Agriculture during the 1936-37 rice season, of panicles of Elon-elon and Ramai, which are this hybrid's parents, and of panicles of Elon-ram (strain No. 2), Elon-ram gave 460 grains per panicle; Elon-elon, 171; and Ramai, 149. In other words, Elon-ram produced 208.7 per cent more grains per panicle than the parent Ramai and 169 per cent more than the Elon-elon parent.

The 1936-37 results of outside plantings of strain No. 2, the seed materials of which were bought from the 1935-36 harvest of the College, were as follows:

Mr. E. Presbitero, an hacendero of Valladolid, Occidental Negros, reported through his son, who is studying in this College, that he obtained a yield of 106 cavans per hectare. He further stated that he would have obtained more if his crop had not been attacked by the rice bug, *Leptocorisa acuta* Thunberg.

Mr. Marcelo R. Abelardo, who bought five cavans of Elon-ram seed palay from the College last 1935-36 crop for a certain Mrs. de Leon of Nueva Ecija, reported as follows:

> "The five cavans yielded more than 500 cavans. The excess over 500 was mixed with the harvest of the other varieties so that the manager cannot give me the exact yield. However, this seems to indicate that this hybrid readily adapts itself to this place. Had it not been for the lack of rain during the first few months after planting, it would have yielded more. They are now planning to plant all Elon-ram disregarding Ramai entirely."

Mr. Antonio S. Alberto reported that in the 1936-37 rice season his tenants in Cabuyao, Laguna, planted seven and one-half hectares of his rice land to Elon-ram. He produced 699 cavans, or an average yield per hectare of 92 cavans. Mr. Alberto claims that he would have obtained a higher yield had it not been for the storm which occurred during the blooming season of the plants.

Mr. F. Ramos, of Guimba, Nueva Ecija, reported an average yield of 96 cavans per hectare on his farm. He further reported that the plants were hardy and were seen to lodge only when the grains began to ripen.

Of particular interest with regard to Elon-ram grown in regions outside the College farm is the observation of Mr. C. Sandico, who grew this rice on his farm at Mexico, Pampanga. From time to time reports were received from Mr. Sandico about the outstanding qual-

ities of this hybrid. Reporting on his 1936-37 crop, he mentioned that the College Elon-ram "is highly resistant to pests, a heavy stooler, and better than any variety" he had planted. To verify this report the writer and Dr. José M. Capinpin visited Mr. Sandico's cultures and made observations on the hybrid on Mr. Sandico's farm on October 29, 1936. From the field stand of Elon-ram in Mexico, it was evident that even after the floods in Central Luzon in the first week of October, 1936, this variety showed hardiness and definite superiority over other rice varieties in withstanding the effect of the flood. The rice fields were suited for the judging of inherent productive capacity of Elon-ram as the plants, grown one to a hill, were spaced wider than in ordinary rice planting. This was done in order to cover as large an area as possible. Mr. Sandico planted his 20 cavans of Elon-ram seed in 25 hectares. Some of the paddies were constructed on highland with little water, some at medium elevation characteristic of ordinary rice paddies, and some in low places which were at times water-logged. In all these conditions the Elon-ram fared satisfactorily. It was observed that in pulling up the Elon-ram seedlings for transplanting, considerable force had to be exerted on account of the deep root system. The abundance and deeper growth of Elon-ram roots seemed to help them resist floods and deep water. The leaves, a few weeks after transplanting, became tough, hairy, and apparently unpalatable to carabaos. This characteristic, according to Mr. Sandico, led some people to believe that Elon-ram is a Java rice, remembering that the Java sugar cane, P. O. J. 2878, is a hard and tough cane. That Elon-ram thrives well even under most adverse conditions of rice growing was shown by the fact that it grew well in one of Mr. Sandico's lots wherein he claimed he could not raise rice or had failed to get a harvest for the last seventeen years. The abundance or scarcity of water in the paddies did not seem to affect the vegetative growth of Elon-ram. Pruning had to be done in order to check its rapid growth and vegetative luxuriance. For instance, seedlings transplanted on May 15 on Mr. Sandico's farm were pruned on October 11, 1936. In some paddies where seedlings were transplanted earlier, pruning was done on July 16 or August 15. On October 29, 1936, some plants were showing early indications of booting. He reported subsequently that he obtained an average yield of 92 cavans per hectare.

The results of the 1936-37 outside plantings of strain No. 2 seed raised by the farmers themselves were as follows:

Mr. A. Manalo, of Cabanatuan, Nueva Ecija, reported that the crop bloomed uniformly and from one hectare he obtained 106 cavans of clean seed palay.

Mr. F. Pineda, of San José, Nueva Ecija, obtained more than 108 cavans per hectare. He further reported that he would not sell any of his Elon-ram seed but would plant all of it this coming rice season.

For convenience, the results of the cultures of Elon-ram strain No. 2 from the fourth generation to the fifth are summarized in table 2.

Table quality. Small samples of milled Elon-ram rice for the 1936-37 College harvest were given to some members of the faculty of this College who were requested to try them and report on their eating quality. The consensus of opinion was that the cooked rice of this hybrid is far better than the Ramai but is slightly inferior to the Elon-elon. The increase in volume when cooked of the milled rice of this hybrid and its parents was determined. It was found that one liter of milled Elon-elon rice increased by 1.3 liters when cooked; Ramai, 1.5 liters; and Elon-ram, 1.8 liters. It is evident from this that the Elon-ram rice increased the most in volume when cooked as compared with both parents. In growing this hybrid, therefore, one may expect, not only an increase in yield per unit area, but also an increase in volume per unit of polished rice cooked, and hence greater economy in rice consumption.

SUMMARY

1. The College Elon-ram rice is a hybrid between Elon-elon and Ramai.

2. On the average, Elon-ram panicles contain 460 grains, about 200 grains more than the panicles of either Elon-elon or Ramai.

3. Based on the 1936-37 crop, or fifth generation culture, the average yield per hectare under College conditions of Elon-ram is 107.9 cavans; of Elon-elon, 67 cavans; and of Ramai, 79.7 cavans.

4. The average yield per hectare of Elon-ram in outside plantings is 100 cavans based on the 1936-37 rice season, or fifth generation, culture.

5. The eating quality of Elon-ram is superior to that of Ramai, but slightly inferior to that of Elon-elon. When cooked, Elon-ram gave an increase of 38 per cent by volume over Elon-elon and 20 per cent over Ramai.

TABLE 1

Uniformity in blooming of Elon-ram plants in row tests

YEAR	HYBRID STRAINS	TOTAL NUMBER OF PLANTS STUDIED	DATE OF FLOWERING	TOTAL NUMBER OF PLANTS THAT BLOOMED AND MATURED UNIFORMLY	TOTAL NUMBER OF PLANTS THAT BLOOMED LATER	PERCENTAGE OF UNIFORMITY OF BLOOMING	DATE OF MATURITY
1933–34	Early	690	Dec. 7, 1933	300	—	43.6	Jan. 9, 1934
			Dec. 14, 1933	245	—	35.5	Jan. 15, 1934
			Jan. 3, 1934	135	—	21.0	Feb. 4, 1934
	Late	966	Dec. 15, 1933	223	—	23.0	Jan. 15, 1934
			Dec. 27, 1933	743	—	76.9	Feb. 4, 1934
1934–35	Strain 1	1207	Dec. 15, 1934	712	495	59.0	Jan. 17, 1935
	" 2	2175	Dec. 30, 1934	1903	273	87.4	Feb. 2, 1935
	" 3	216	Dec. 9, 1934	110	105	48.5	Jan. 9, 1935
	" 4	619	Dec. 14, 1934	365	254	58.9	Jan. 16, 1935
	" 5	565	Jan. 2, 1935	339	226	60.0	Feb. 3, 1935
1935–36	Strain 1	1916	Dec. 15, 1935	1590	326	82.9	Jan. 16, 1936
	" 2	4677	Dec. 28, 1935	4443	234	95.0	Jan. 31, 1936
	" 3	250	Dec. 10, 1935	203	47	81.0	Jan. 9, 1936
	" 4	3715	Dec. 14, 1935	3381	334	91.0	Jan. 16, 1936
	" 5	2317	Jan. 4, 1936	2039	278	88.0	Feb. 3, 1936
1936–37	Strain 1	2400	Dec. 15, 1936	2265	135	94.3	Jan. 16, 1937
	" 2	5700	Dec. 27, 1936	5601	99	98.2	Jan. 29, 1937
	" 3	300	Dec. 9, 1936	261	39	86.2	Jan. 9, 1937
	" 4	4100	Dec. 14, 1936	3813	287	93.0	Jan. 15, 1937
	" 5	3100	Jan. 2, 1937	2836	264	91.7	Feb. 1, 1937

TABLE 2

Results of cultures of Elon-ram
1935-1936

NAME OF PLANTER	SOURCE OF SEED	AREA OR AMOUNT OF SEED PLANTED	ACTUAL YIELD	COMPUTED YIELD PER HECTARE	REMARKS BY PLANTERS
		gantas	*cavans*	*cavans*	
1. A. Cangao	College 1934–35 crop	21	91.0	91.0	The plants grew about 1.5 meters high. They bloomed uniformly.
2. W. Dionido	"	1	6.5	136.5	The plants grew more vigorously than Inadhica and produced more tillers per hill than Inadhica.
3. A. Manalo	"	1	6.7	130.2	Not bothered by flood; bloomed uniformly.
4. F. Pineda	"	1	5.6	117.6	Plants grew vigorously, panicles exceptionally big and long.

TABLE 2 (continued)
1936-1937

NAME OF PLANTER	SOURCE OF SEED	AREA OR AMOUNT OF SEED PLANTED	ACTUAL YIELD	COMPUTED YIELD PER HECTARE	REMARKS BY PLANTERS
1. P. Lalap	College 1935–36 crop	12.5	59.7	100.30	Heavy tillering with very long and big panicles.
2. Agronomy 13 students	”	12.5	79.1	132.90	” ” ” ” ” ” ” ”
3. M. Lawas	”	14.0	61.0	91.50	” ” ” ” ” ” ” ”
4. A. Banasihan	”	14.0	60.1	90.15	” ” ” ” ” ” ” ”
5. B. Monasteria	”	14.0	59.6	89.40	” ” ” ” ” ” ” ”
6. E. Tamis	”	7.0	31.0	93.00	” ” ” ” ” ” ” ”
7. N. Castro	”	7.0	30.0	90.00	” ” ” ” ” ” ” ”
8. J. Gibe	”	7.0	28.4	85.20	” ” ” ” ” ” ” ”
9. J. Garcia	”	5.0	21.0	90.00	” ” ” ” ” ” ” ”
10. B. Lapitan	”	7.0	32.0	96.00	” ” ” ” ” ” ” ”
11. E. Presbitero	”	21.0	106.0	106.00	The plants would have given higher yield if it had not been for the attack of rice bug.
12. N. Abelardo	”	125.0	500.0	—	The plants would have given higher yield if there had been sufficient rain during the early development of the plants.
13. A. Alberto	”	157.5	699.0	92.00	The plants would have yielded more if there had not been inclement weather (storm) which prevailed during the blooming time of the plants.
14. F. Ramos	”	375.0	—	96.00	A higher yield would have been obtained had there not been a lack of rain.
15. C. Sandico	”	500.0	—	92.00	Withstood effects of floods.
16. F. Pineda	Planter’s 1935–36 crop	21.0	108.0	108.00	A part of the crop was damaged by rice bug.
17. A. Manalo	”	21.0	106.0	106.00	Withstood effects of floods.

CITRIC ACID AS A REAGENT IN THE GRAVIMETRIC METHOD OF DETERMINING SOIL IRON IN HYDROCHLORIC ACID SOLUTION [1]

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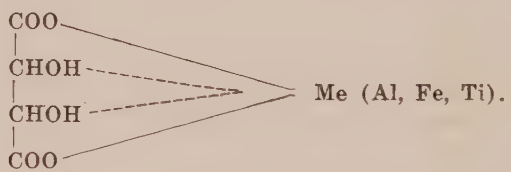
Although citric acid was reported by Treadwell and Hall (1921) to have the property of preventing the precipitation of certain metallic hydroxides from solutions of their salts, its use as a reagent in the gravimetric method of determining soil iron has never been mentioned. It should be of interest, therefore, to ascertain its value when used as such. The data should be important, even if they have no advantage over the accepted reagent, for the reason that citric acid may serve as its alternate.

Because of the theoretical and practical importance of iron in the study of soils, literature on the subject of methods for its determination is voluminous. Rieser (1931) reported, however, in his comprehensive and extensive review of the different methods of determining soil iron in HCl in the presence of the other soil constituents only one reagent for the gravimetric method, namely, tartaric acid. This method, which is not only extensively but also intensively used, is based on the fact that tartaric acid has the ability to form with the metals in solution inner complex salts, having abnormal physical properties. The formula of these salts, as given by Rieser (1931), is



On saturating this solution with hydrogen sulfide gas, the trivalent iron is converted into divalent and likewise its bonds are broken from the complex compounds. Thus, on being made slightly alkaline with NH_4OH, a complete precipitation and at the same time a quantitative separation of FeS from the rest of the soil constituents are attained.

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[1] Experiment Station contribution No. 1213. Read before the Los Baños Biological Club November 18, 1937.

After this the FeS precipitate is dissolved in warm dilute HCl, oxidized, and precipitated as $Fe(OH)_3$. Up to the time of this paper, the writer has been unable to find an alternate reagent for tartaric acid in the survey of the existing gravimetric methods.

The present paper aims, therefore, to study the behavior of citric acid as a reagent in the gravimetric method of determining soil iron in hydrochloric acid solution.

MATERIALS AND METHODS

The citric acid as well as the tartaric acid used in the present study are both contained in 5-pound bottles, labeled Baker's C. P. Analyzed, are white in color, and transparent crystalls in form. Each contains, as shown on the label, 0.0005 per cent iron, which is equivalent to 0.0007 per cent Fe_2O_3.

Soil solution in hydrochloric acid employed to accomplish the purpose was prepared by treating Nanhaya clay with 10 per cent HCl in a manner similar to the method recommended by the second commission of the International Society of Soil Science, as modified by Blanck and Rieser (1928). The method reads as follows: Twenty grams of soil, which have passed through a 2 mm. mesh sieve, are refluxed with 100 ml. 10 per cent HCl for 4 hours on a boiling water bath, after which it is filtered into a 500-ml. casserole, washed with warm water until free from chlorides, and evaporated to dryness on a boiling water bath. The residue is treated with a few ml. concentrated HNO_3 and evaporated again to dryness to remove the organic matter. To attain a complete dehydration and separation of the silica contained therein, the residue is treated with 1:1 HCl and evaporated as usual, at least three times. It is dissolved in 200 ml. 1:1 HCl, covered with a watch glass, and allowed to remain on a warm water bath until the solution appears non-colloidal. Then it is filtered, and the filtrate is received into a 500 ml. volumetric flask. The silica is first washed with warm dilute HCl until it is white and then with warm water till free from chlorides. The solution is made up to the mark and analyzed for its content on inorganic soil constituents, the amounts of which are 0.16 per cent TiO_2, 9.85 per cent Al_2O_3, 7.10 per cent Fe_2O_3, 0.66 per cent CaO, 0.48 per cent MgO, 0.13 per cent K_2O, 0.21 per cent Na_2O, 0.03 per cent P_2O_5, and 0.06 per cent SO_3.

The technique of the method followed in the determination of iron using tartaric acid is as follows: An aliquot portion of the solution is diluted in an Erlenmeyer flask with an equal volume of

water. To this, tartaric acid, which is usually three or four times as much as the amount of the sesquioxides in solution, is now added, and the solution is shaken until the tartaric acid is completely dissolved. Hydrogen sulfide gas is generated into the solution until it appears white or saturated. This reduces the ferric ion into a ferrous ion. The solution is made slightly alkaline with NH_4OH, and some more H_2S gas is generated into it. An excess of NH_4OH should be avoided because it not only retards the coagulation of the black ferrous sulfide precipitate, but also gives a turbid filtrate containing colloidal ferrous sulfide which may be detected by passing more H_2S gas into the filtrate. It indicates, then, that too much NH_4OH is conducive to incomplete separation of iron from the other metals in solution. The flask is covered with a watch glass or with the cover of a porcelain crucible, placed on a warm water bath until the precipitate has coagulated, and the solution then filtered in such a way that the filter does not become empty. With the same precaution, the precipitate is washed with 10 ml. freshly prepared $(NH_4)_2S$ solution four times or until the washing is white. Incomplete removal of tartaric acid causes the formation of colloidal ferric hydroxide during the precipitation of iron, which not only is hard to filter but also gives low results. A complete separation of iron from the rest of the soil constituents is confirmed by a clear lemon yellow filtrate. The precipitate of FeS is dissolved with warm dilute HCl, boiled until the solution is clear, treated with a few ml. of concentrated HNO_3, or better yet with hydrogen peroxide, and made slightly alkaline with NH_4OH to precipitate the iron as $Fe(OH)_3$.

The analytical procedure followed in using citric acid is exactly the same as that given under tartaric acid.

In order to ascertain the consistency of the results, seven determinations were made from each of the aliquot portions. The results of the analysis are given in table 1.

RESULTS AND DISCUSSION

It is apparent from the data shown in table 1 that the weights in grams of Fe_2O_3 in the 50 ml. sample range under the citric acid column from 0.1339 to 0.1360 gram, or in percentages from 7.06 to 7.16 per cent. Those under the tartaric acid column vary from 0.1346 to 0.1363 gram, corresponding to 7.10 to 7.18 per cent respectively. Their average weights and, consequently, their average percentages do not show very appreciable differences from each other. The value of these are 7.09 $\pm$ 0.009 per cent for the reagent in question and 7.12 $\pm$ 0.009 per cent for tartaric acid.

A study of the rest of the figures in table 1, namely, those in the 45, 40, 35, 30, 25, 20, 15, 10, and 5 ml. samples, reveals a close parallelism between the results obtained with the use of citric acid and those obtained with tartaric acid. When these average percentages of Fe_2O_3 are treated statistically, insignificant differences are obtained in all the series, as may be seen in table 1a. The figures in this table further indicate that the ten series of determinations, namely, 50, 45, 40, 35, 30, 25, 20, 15, 10, and 5 ml., carried out with the use of the reagent in question, have relatively the same magnitude of standard deviation and coefficient of variation as the corresponding series under the tartaric acid column. These findings suggest that in the absence of tartaric acid, citric acid may be used in the determination of soil iron in hydrochloric acid solution.

Table 1 also shows that as the volume of the aliquot sample is decreased, the average percentage of Fe_2O_3 given under both reagents becomes high, as brought out by the results in the 10 and 5 ml. samples. The values are 7.27 ± 0.026 and 7.35 ± 0.024 per cent for the citric acid and 7.36 ± 0.022 and 7.44 ± 0.034 per cent for the tartaric acid. These are apparently higher than the corresponding values in the bigger aliquot samples. This finding, which is in concordance with the common experience observed in using very small samples in the gravimetric work, may be attributed to the fact that the very small unavoidable errors encountered in the determination are magnified greatly by the dilution factor.

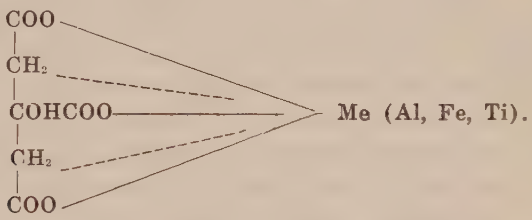
In order that the validity of citric acid as a reagent in the gravimetric method of determining soil iron in hydrochloric acid solution might be further verified, it was used in soil solutions of lower concentrations. The results of the analysis are contained in tables 2 and 3.

It is apparent in table 2 that the highest differences are shown by the average percentage amount of Fe_2O_3 in the 25 and 15 ml. series. Statistical treatment of these values, as given in table 2a, shows that there are no real differences except those indicated by the 25 and 15 ml. samples, which are significantly higher in favor of tartaric acid. The data in table 2a reveal also that the amount of iron obtained by the use of citric acid are as concordant as those obtained by the use of tartaric acid since the differences in the coefficient of variation of the two sets of values are all insignificant.

Table 3 establishes that, in general, citric acid may be used interchangeably with tartaric acid. Out of six series of determinations, only two showed evident differences in the average percentage

amount of Fe_2O_3, as may be seen in table 3a. As to the agreement of the two sets of values, it may be pointed out again that the results in the six series of determinations corroborate the conclusion drawn in the above discussions; that is, the results obtained by the use of citric acid compared with the corresponding series of tartaric acid show in all cases insignificant differences in their standard deviation and in their coefficient of variation.

Out of the total 21 series of determinations made, 17 proved to have the same average values as the corresponding series given by tartaric acid. It may be inferred, then, that citric acid when used as a reagent in the gravimetric method of determining soil iron in hydrochloric acid solution behaves in a manner similar to tartaric acid. For a better understanding of the theory involved, the complex salts which it forms with the inorganic soil constituents may be represented by the formula



When these complex salts are saturated with H_2S gas and NH_4OH is subsequently added in slight excess, a quantitative separation of iron from the rest of the soil constituents results, after which the ferrous sulfide is dissolved in warm dilute HCl, oxidized, and precipitated with NH_4OH as $Fe(OH)_3$.

SUMMARY AND CONCLUSIONS

From the foregoing discussion, the following conclusions may be drawn:

1. The precautions which should be observed and which are very essential in obtaining concordant results are given in the method of analysis.

2. Out of 21 series of determinations made with citric acid and tartaric acid, in only 4 were the two sets of values not statistically in good agreement; this means that about 81 per cent of the determinations made with citric acid gave results as reliable as those obtained with tartaric acid.

3. Citric acid used as a reagent in the gravimetric method of determining soil iron gave the same magnitude of standard deviation and coefficient of variation as tartaric acid.

4. The use of citric acid as an alternate of tartaric acid in the gravimetric determination of soil iron may be recommended. For this purpose, it first forms, with the metals in solution, complex salts not precipitable with NH_4OH. When this solution is saturated with H_2S gas, iron is reduced to a ferrous condition which when made slightly alkaline with NH_4OH causes the complete separation of iron as ferrous sulfide from the rest of the soil constituents.

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TABLE 1

Amount of Fe_2O_3 obtained by the use of citric and tartaric acid reagents

ML. OF SOLUTION USED	USING CITRIC ACID		USING TARTARIC ACID	
	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3
50	0.1341	7.07	0.1346	7.10
50	0.1360	7.16	0.1348	7.10
50	0.1347	7.10	0.1351	7.12
50	0.1339	7.06	0.1348	7.07
50	0.1344	7.08	0.1363	7.18
50	0.1342	7.07	0.1355	7.14
50	0.1350	7.11	0.1349	7.11
Average ...	0.1345	7.09 ± 0.009	0.1351	7.12 ± 0.009
45	0.1220	7.14	0.1230	7.18
45	0.1240	7.24	0.1237	7.22
45	0.1232	7.22	0.1227	7.16
45	0.1238	7.23	0.1231	7.20
45	0.1226	7.18	0.1232	7.20
45	0.1224	7.16	0.1228	7.16
45	0.1221	7.09	0.1222	7.14
Average ...	0.1229	7.18 ± 0.014	0.1230	7.18 ± 0.007
40	0.1082	7.13	0.1090	7.18
40	0.1094	7.22	0.1079	7.10
40	0.1091	7.20	0.1082	7.12
40	0.1103	7.24	0.1091	7.18
40	0.1073	7.08	0.1088	7.16
40	0.1087	7.16	0.1086	7.15
40	0.1089	7.18	0.1104	7.26
Average ...	0.1089	7.16 ± 0.014	0.1089	7.16 ± 0.009
35	0.0955	7.17	0.0947	7.13
35	0.0951	7.15	0.0960	7.22
35	0.0947	7.12	0.0952	7.16
35	0.0960	7.22	0.0949	7.14
35	0.0946	7.12	0.0947	7.13
35	0.0948	7.13	0.0950	7.15
35	0.0950	7.14	0.0962	7.23
Average ...	0.0951	7.15 ± 0.009	0.0952	7.17 ± 0.009
30	0.0825	7.24	0.0817	7.16
30	0.0818	7.18	0.0820	7.20
30	0.0819	7.18	0.0819	7.20
30	0.0811	7.12	0.0817	7.16
30	0.0822	7.22	0.0819	7.20
30	0.0815	7.16	0.0832	7.29
30	0.0820	7.20	0.0816	7.16
Average ...	0.0819	7.19 ± 0.010	0.0820	7.20 ± 0.012

TABLE 1 (continued)

ML. OF SOLUTION USED	USING CITRIC ACID		USING TARTARIC ACID	
	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3
25	0.0673	7.09	0.0675	7.11
25	0.0660	6.94	0.0672	7.08
25	0.0676	7.12	0.0674	7.10
25	0.0671	7.07	0.0680	7.16
25	0.0673	7.10	0.0685	7.22
25	0.0674	7.10	0.0659	6.93
25	0.0680	7.16	0.0670	7.06
Average ...	0.0673	7.08 ± 0.017	0.0674	7.09 ± 0.023
20	0.0545	7.18	0.0550	7.25
20	0.0540	7.11	0.0548	7.22
20	0.0542	7.13	0.0552	7.27
20	0.0547	7.20	0.0547	7.22
20	0.0539	7.10	0.0544	7.16
20	0.0541	7.12	0.0546	7.20
20	0.0547	7.20	0.0540	7.11
Average ...	0.0543	7.15 ± 0.012	0.0547	7.20 ± 0.014
15	0.0405	7.14	0.0409	7.20
15	0.0411	7.22	0.0410	7.22
15	0.0408	7.18	0.0406	7.14
15	0.0404	7.11	0.0408	7.18
15	0.0409	7.18	0.0411	7.22
15	0.0407	7.15	0.0408	7.18
15	0.0420	7.37	0.0427	7.47
Average ...	0.0408	7.19 ± 0.022	0.0411	7.23 ± 0.020
10	0.0280	7.37	0.0269	7.33
10	0.0270	7.11	0.0284	7.47
10	0.0272	7.16	0.0277	7.28
10	0.0278	7.32	0.0280	7.37
10	0.0281	7.40	0.0281	7.40
10	0.0277	7.28	0.0283	7.44
10	0.0273	7.19	0.0275	7.23
Average ...	0.0276	7.27 ± 0.026	0.0280	7.36 ± 0.022
5	0.0140	7.37	0.0141	7.42
5	0.0138	7.27	0.0139	7.32
5	0.0140	7.37	0.0144	7.57
5	0.0142	7.47	0.0143	7.52
5	0.0137	7.22	0.0140	7.37
5	0.0139	7.32	0.0145	7.62
5	0.0141	7.42	0.0138	7.26
Average ...	0.0140	7.35 ± 0.024	0.0142	7.44 ± 0.034

TABLE 1a

Comparison of the average percentage amount of Fe_2O_3

ML.	MEAN		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	7.09 ± 0.009	7.12 ± 0.009	0.03 ± 0.013
45	7.18 ± 0.014	7.18 ± 0.007	0.00 ± 0.016
40	7.16 ± 0.014	7.16 ± 0.009	0.00 ± 0.017
35	7.15 ± 0.009	7.17 ± 0.009	0.02 ± 0.013
30	7.19 ± 0.010	7.20 ± 0.012	0.01 ± 0.016
25	7.08 ± 0.017	7.09 ± 0.023	0.01 ± 0.029
20	7.15 ± 0.012	7.20 ± 0.014	0.05 ± 0.018
15	7.19 ± 0.022	7.23 ± 0.020	0.04 ± 0.030
10	7.27 ± 0.026	7.36 ± 0.022	0.09 ± 0.034
5	7.35 ± 0.024	7.44 ± 0.034	0.09 ± 0.042

ML.	STANDARD DEVIATION		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	0.032 ± 0.006	0.033 ± 0.006	0.001 ± 0.009
45	0.051 ± 0.009	0.026 ± 0.005	0.025 ± 0.010
40	0.053 ± 0.010	0.032 ± 0.006	0.019 ± 0.116
35	0.033 ± 0.006	0.039 ± 0.007	0.006 ± 0.009
30	0.037 ± 0.007	0.043 ± 0.008	0.006 ± 0.010
25	0.064 ± 0.012	0.064 ± 0.012	0.000 ± 0.017
20	0.039 ± 0.007	0.051 ± 0.009	0.012 ± 0.011
15	0.080 ± 0.014	0.071 ± 0.013	0.009 ± 0.019
10	0.095 ± 0.017	0.080 ± 0.014	0.015 ± 0.022
5	0.085 ± 0.015	0.125 ± 0.023	0.040 ± 0.027

ML.	COEFFICIENT OF VARIATION		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	0.466 ± 0.084	0.464 ± 0.084	0.002 ± 0.118
45	0.710 ± 0.128	0.362 ± 0.065	0.348 ± 0.143
40	0.740 ± 0.133	0.446 ± 0.080	0.294 ± 0.155
35	0.462 ± 0.083	0.543 ± 0.098	0.081 ± 0.128
30	0.515 ± 0.093	0.597 ± 0.107	0.082 ± 0.107
25	0.904 ± 0.162	0.902 ± 0.162	0.002 ± 0.226
20	0.945 ± 0.170	0.909 ± 0.163	0.036 ± 0.235
15	1.115 ± 0.201	0.982 ± 0.176	0.133 ± 0.268
10	1.305 ± 0.235	1.085 ± 0.196	0.220 ± 0.308
5	1.158 ± 0.284	1.680 ± 0.303	0.522 ± 0.412

TABLE 2

Amount of Fe_2O_3 obtained by the use of citric and tartaric acid reagents
Dilution factor 1.46

ML. OF SOLUTION USED	USING CITRIC ACID		USING TARTARIC ACID	
	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3
50	0.0974	4.87 × 1.46	0.0972	4.86 × 1.46
50	0.0970	4.85 "	0.0960	4.80 "
50	0.0980	4.90 "	0.0985	4.93 "
50	0.0976	4.88 "	0.0981	4.91 "
50	0.0971	4.86 "	0.0982	4.91 "
50	0.0965	4.83 "	0.0987	4.94 "
50	0.0968	4.84 ±"	0.0985	4.93 "
Average	0.0972	4.86 ± 0.006	0.0979	4.90 ± 0.012
25	0.0482	4.82 × 1.46	0.0498	4.98 × 1.46
25	0.0487	4.87 "	0.0503	5.03 "
25	0.0480	4.80 "	0.0500	5.00 "
25	0.0485	4.85 "	0.0494	4.94 "
25	0.0494	4.94 "	0.0497	4.97 "
25	0.0487	4.87 "	0.0491	4.96 "
25	0.0484	4.84 "	0.0495	4.95 "
Average	0.0485	4.86 ± 0.012	0.0498	4.98 ± 0.008
15	0.0298	4.96 × 1.46	0.0311	5.18 × 1.46
15	0.0287	4.78 "	0.0300	5.00 "
15	0.0300	5.00 "	0.0301	5.02 "
15	0.0290	4.83 "	0.0300	5.00 "
15	0.0294	4.90 "	0.0301	5.02 "
15	0.0289	4.82 "	0.0303	5.05 "
15	0.0299	4.98 "	0.0298	4.96 "
Average	0.0294	4.90 ± 0.022	0.0303	5.03 ± 0.018
10	0.0196	4.90 × 1.46	0.0213	5.13 × 1.46
10	0.0201	5.02 "	0.0210	5.10 "
10	0.0207	5.07 "	0.0205	5.05 "
10	0.0200	5.00 "	0.0207	5.07 "
10	0.0202	5.02 "	0.0211	5.11 "
10	0.0198	4.95 "	0.0199	4.98 "
10	0.0199	4.98 "	0.0206	5.06 "
Average	0.0199	4.99 ± 0.022	0.0207	5.07 ± 0.013
5	0.0114	5.70 × 1.46	0.0112	5.60 × 1.46
5	0.0120	6.00 "	0.0110	5.50 "
5	0.0105	5.25 "	0.0112	5.60 "
5	0.0108	5.40 "	0.0111	5.55 "
5	0.0109	5.45 "	0.0104	5.20 "
5	0.0110	5.50 "	0.0113	5.65 "
5	0.0106	5.30 "	0.0110	5.50 "
Average	0.0110	5.50 ± 0.044	0.0110	5.50 ± 0.039

TABLE 2a

Comparison of the average percentage of Fe_2O_3

ML.	MEAN		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	4.86 ± 0.006	4.90 ± 0.012	0.04 ± 0.014
25	4.86 ± 0.012	4.98 ± 0.008	0.12 ± 0.015 [s]
15	4.90 ± 0.022	5.03 ± 0.018	0.13 ± 0.028 [s]
10	4.99 ± 0.022	5.07 ± 0.013	0.08 ± 0.027
5	5.50 ± 0.044	5.50 ± 0.039	0.00 ± 0.059

ML.	STANDARD DEVIATION		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	0.022 ± 0.004	0.047 ± 0.008	0.025 ± 0.009
25	0.042 ± 0.008	0.029 ± 0.005	0.013 ± 0.009
15	0.081 ± 0.014	0.065 ± 0.012	0.016 ± 0.018
10	0.050 ± 0.009	0.046 ± 0.008	0.004 ± 0.012
5	0.241 ± 0.043	0.145 ± 0.026	0.096 ± 0.050

ML.	COEFFICIENT OF VARIATION		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	0.452 ± 0.081	0.960 ± 0.172	0.508 ± 0.190
25	0.864 ± 0.155	0.582 ± 0.105	0.282 ± 0.187
15	1.655 ± 0.297	1.685 ± 0.238	0.030 ± 0.382
10	1.000 ± 0.180	0.907 ± 0.163	0.093 ± 0.243
5	4.375 ± 0.785	2.641 ± 0.475	1.734 ± 0.861

[s] Significant.

TABLE 3

Amount of Fe_2O_3 obtained by the use of citric and tartaric acid as reagents
Dilution factor 1.93

ML. OF SOLUTION USED	USING CITRIC ACID		USING TARTARIC ACID	
	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3
50	0.0748	3.74 × 1.93	0.0752	3.76 × 1.93
50	0.0732	3.66 ”	0.0760	3.80 ”
50	0.0748	3.74 ”	0.0740	3.70 ”
50	0.0741	3.71 ”	0.0755	3.78 ”
50	0.0730	3.65 ”	0.0750	3.75 ”
50	0.0737	3.69 ”	0.0750	3.75 ”
50	0.0733	3.57 ”	0.0753	3.77 ”
Average	0.0738	3.69 ± 0.016	0.0751	3.76 ± 0.008
25	0.0368	3.68 × 1.93	0.0395	3.95 × 1.93
25	0.0385	3.85 ”	0.0386	3.86 ”
25	0.0378	3.78 ”	0.0395	3.95 ”
25	0.0384	3.84 ” [a]	0.0380	3.80 ” [a]
25	0.0370	3.70 ” [a]	0.0386	3.86 ” [a]
25	0.0388	3.88 ” [a]	0.0393	3.93 ” [a]
25	0.0385	3.85 ” [a]	0.0382	3.82 ” [a]
Average	0.0380	3.80 ± 0.018	0.0389	3.89 ± 0.014
20	0.0305	3.82 × 1.93	0.0302	3.77 × 1.93
20	0.0301	3.76 ”	0.0308	3.85 ”
20	0.0304	3.80 ”	0.0320	4.00 ”
20	0.0314	3.93 ”	0.0322	4.02 ”
Average	0.0306	3.83 ± 0.025	0.0313	3.91 ± 0.041
15	0.0228	3.80 × 1.93	0.0234	3.91 × 1.93
15	0.0237	3.95 ”	0.0237	3.95 ”
15	0.0232	3.87 ”	0.0236	3.93 ”
15	0.0240	4.00 ”	0.0237	3.95 ”
15	0.0232	3.87 ”	0.0242	4.05 ”
15	0.0231	3.86 ”	0.0237	3.95 ”
15	0.0238	3.97 ”	0.0240	4.00 ”
Average	0.0234	3.90 ± 0.018	0.0238	3.96 ± 0.014
10	0.0165	4.13 × 1.93	0.0168	4.20 × 1.93
10	0.0155	3.88 ”	0.0156	3.90 ”
10	0.0165	4.13 ”	0.0169	3.98 ”
10	0.0161	4.02 ”	0.0172	4.29 ”
10	0.0155	3.88 ”	0.0166	4.15 ”
10	0.0158	3.95 ”	0.0155	3.88 ”
10	0.0161	4.02 ”	0.0157	3.92 ”
10	0.0162	4.05 ”	0.0162	4.05 ”
Average	0.0160	4.01 ± 0.024	0.0163	4.05 ± 0.036

[a] These figures were determined by Mr. A. L. Madamba, a member of the senior class and a student assistant in the department.

TABLE 3 (continued)

ML. OF SOLUTION USED	USING CITRIC ACID		USING TARTARIC ACID	
	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3	Wt. in grams of Fe_2O_3	Per cent of Fe_2O_3
5	0.0078	3.90 × 1.93	0.0085	4.25 × 1.93
5	0.0074	3.70 "	0.0084	4.20 "
5	0.0082	4.10 "	0.0080	4.00 "
5	0.0082	4.10 "	0.0081	4.05 "
5	0.0086	4.30 "	0.0084	4.20 "
5	0.0085	4.25 "	0.0081	4.05 "
5	0.0080	4.00 "	0.0082	4.10 "
Average	0.0081	4.05 ± 0.053	0.0082	4.12 ± 0.024

TABLE 3a

Comparison of the average percentage of Fe_2O_3

ML.	MEAN		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	3.69 ± 0.016	3.76 ± 0.008	0.07 ± 0.018 [s]
25	3.80 ± 0.018	3.89 ± 0.074	0.09 ± 0.023 [s]
20	3.83 ± 0.025	3.91 ± 0.041	0.08 ± 0.048
15	3.90 ± 0.018	3.96 ± 0.014	0.06 ± 0.021
10	4.01 ± 0.024	4.05 ± 0.036	0.04 ± 0.043
5	4.05 ± 0.053	4.12 ± 0.024	0.07 ± 0.059

ML.	STANDARD DEVIATION		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	0.057 ± 0.010	0.029 ± 0.005	0.028 ± 0.011
25	0.069 ± 0.012	0.058 ± 0.010	0.011 ± 0.015
20	0.063 ± 0.015	0.104 ± 0.025	0.041 ± 0.028
15	0.067 ± 0.012	0.050 ± 0.009	0.017 ± 0.015
10	0.094 ± 0.016	0.143 ± 0.024	0.049 ± 0.029
5	0.191 ± 0.034	0.082 ± 0.015	0.109 ± 0.037

ML.	COEFFICIENT OF VARIATION		DIFFERENCES
	Citric acid	Tartaric acid	
	per cent	*per cent*	*per cent*
50	1.531 ± 0.275	0.773 ± 0.139	0.758 ± 0.304
25	1.823 ± 0.307	1.495 ± 0.252	0.328 ± 0.397
20	1.655 ± 0.394	2.661 ± 0.634	1.006 ± 0.741
15	1.708 ± 0.306	1.265 ± 0.227	0.443 ± 0.381
10	2.350 ± 0.396	3.530 ± 0.595	1.180 ± 0.712
5	4.710 ± 0.848	1.991 ± 0.358	2.720 ± 0.924

[s] Significant.

VOCATIONAL EDUCATION STUDIES: I. OCCUPATIONAL BACKGROUND AND VOCATIONAL CHOICE OF HIGH SCHOOL SENIORS [1]

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There is a rapidly growing interest in vocational education in this country, as shown by recent changes and newly contemplated modifications in our public school system. Other evidences of the trend towards vocational training are the passage in 1927 of Act 3377, the Vocational Education Act, the employment by the Philippine Government in 1930 of Dr. Charles Prosser, an expert in vocational education, and the appointment by the President of the Commonwealth of an Educational Survey Committee and, recently, of a National Council on Education. This Council, like the previous committee, believes that the present system of secondary education, wherein the majority of students are in the academic curriculum, needs modification. The Council recommends that, instead of a purely academic education, the high school student should pursue a type of education that includes vocational training.[2]

To become effective, the program of vocational training which will be established to meet the need for this type of education must be based on existing economic and educational conditions. It must be organized on the basis of pertinent facts, such as, the types of occupations in which youths should be trained, the number to be trained in each vocation, the length of the training period necessary, the standard of proficiency needed, the age of pupils who should receive training, the grades in the school system when vocational instruction should be introduced, and the attitude of parents and of pupils towards particular vocations. Unfortunately, educational research has barely touched the field of vocational education. Even the Monroe Commission (1925), which urged the shift of emphasis to vocational education, failed to include in its report data upon which a sound system of vocational training may be formulated. It is the purpose

[1] Experiment Station contribution No. 1214. Received for publication November 17, 1937.

[2] The Tribune, July 25, 1937.

of this series of studies to throw some light on the various aspects of this important educational problem.

Importance of the present investigation

A knowledge of the occupational interests of youths in schools is of value to the vocational counsellor and the administrator of vocational education. It enables the counsellor to know the attitudes of youths toward particular vocations. Prejudice against certain occupations may be discovered, in which case, changes of attitude may have to be made. Choice of certain lines of work by a number larger than may be expected to be profitably employed may necessitate also proper counselling and guidance. The vocational counselor will be able to give additional information on those vocations chosen and thereby acquaint the pupils more closely with the demands and problems of the particular occupational pursuit. To the school administrator, a knowledge of the vocational interests of students may reveal the type of schools and nature of courses which should be established to prepare future workers.

Information concerning the occupations of parents of pupils is also important because it indicates the occupational background and experience of students. The occupational distribution of parents may serve the school administrator as an index in determining the relative number that should be prepared to replace those who quit through retirement, death, or other causes.

Review of literature

Very limited work has been undertaken in the Philippines on the vocational choice and occupational background of high school seniors. A recent study of the choice of occupation of academic high school seniors was made by Magtira (1937). This survey, which was limited to a graduating class of the U. P. High School in Manila, showed that of the 92 students 14.14 per cent selected law; 6.52 per cent, business; and only 2.17 per cent, agriculture.

In a study on the occupational choice of agricultural high school boys, Sacay (1933) found that 37.8 per cent intended to farm immediately after schooling and 24.1 per cent after accumulating sufficient capital; 24.4 per cent selected teaching; 3.9 per cent, professional service; and the rest chose commerce, clerical work, and skilled labor.

In the State of New York, Eaton (1922) reported that, in the case of boys enrolled in the agricultural course, 76.12 per cent chose agricultural occupations, and 23.88 per cent, non-agricultural. The percentage of seniors who planned to go to college was 69.9.

Regarding the parental occupations of the 496 high school seniors in Occidental Negros, Pangasinan, Sorsogon, and Cebu, the Monroe Educational Survey Commission reported the following distribution: farm owners, 50.0 per cent; farm tenants, 3.0 per cent; merchants and proprietors of business, 22.8; managers and officials, 8.1; clerical and commercial service, 3.7; professional service, 3.4; artisans and skilled laborers, 4.8; fishermen, 1.8; common laborers, 1.4; unclassified, 1.0 per cent.

Objects of the present paper

The principal objects of the present study are: (*a*) to discover the vocational intentions of seniors of several academic high schools; (*b*) to get a picture of the distribution of occupations as revealed by the pursuits of parents of students; and (*c*) to determine the proportion of pupils selecting occupations similar to those of their parents.

Method of study

The present study includes 1,151 senior students enrolled in nine academic high schools located in different parts of the Islands: namely, Batangas, Capiz, Cavite, Ilocos Norte, Laguna, Leyte, Nueva Ecija, Pangasinan, and Zambales. In certain schools, the data dealt with the seniors who expected to graduate in 1935; in other schools, data were for those graduating in March, 1936.

In securing the necessary information, a questionnaire was prepared and copies of it sent to the different high schools two or three weeks before the date of graduation. By that time, many of the seniors had probably given considerable thought to their vocational and educational plans for the future. The replies of the students were collected by the principals and sent to the writer.

RESULTS AND DISCUSSION

The results of the present survey may be found in tables 1 to 6.

Educational intentions

It may be seen in table 1 that of the 1,151 seniors, 800, or 69.5 per cent, were males. There were more boys than girls in the different high schools surveyed. The smaller number of girls was due, in some cases, to the presence of schools for girls in towns where the public high schools were located.

In table 1 is also shown that 77.5 per cent intended to go to college, 18.6 per cent did not, while only 3.9 per cent were doubtful.

The percentage intending to pursue higher education was greater among boys than among girls, the percentage being 79.4 per cent and 73.2 per cent, respectively.

Occupations of parents of male students

The occupations of parents of male students may indicate the social composition of the people in a given district. The relative importance of different occupational groups may serve as a basis for determining the emphasis to be given to various training courses.

In table 2 are shown the different occupations pursued by the fathers of 710 male seniors. There were 22 different types of occupations. The percentage engaged in important occupations was: (1) farmer, 51.1 per cent; (2) businessman, 12.8; (3) fisherman, 3.8; (4) unskilled laborer, 3.6; (5) employee, 3.1; (6) clerk, 3.1; (7) carpenter, 2.8; (8) mechanic, 2.1. Only a few were engaged in professional work, as follows: (1) lawyer, 1.7 per cent; (2) teacher, 1.4 per cent. There were 1 dentist, 1 engineer, 1 pharmacist, and 2 physicians.

The above figures reveal that farming and business are important occupations. A large number should, therefore, be trained for these activities.

Choice of occupations of male seniors

The occupational choice of male seniors is shown in table 3. Of the 625 who planned to go to College, 15.1 per cent selected farming; 14.4 per cent, law; 9.6, engineering; 9.1, medicine; 8.8, business; 5.9, aviation; 5.4, military service; 5.4, chemistry; 5.1, teaching; 3.5, naval service. Thirty-seven types of vocational pursuits were included. It will also be observed that a large proportion, 42.7 per cent, wanted to engage in the professions of law, medicine, engineering, dentistry, and teaching.

The choice of the male seniors who did not intend to go to college, or who were doubtful as to what to do next, was limited to a few occupations. The majority selected as follows: farming, 27.9 per cent; business, 14.5; military service, 13.3; and mechanics, 6.7. While those intending to go to College selected professional or semi-professional pursuits, those who did not have a desire to go to college chose the more common vocations.

Occupational choice of female seniors

As table 4 shows, 26.4 per cent of the girls intending to go to college selected teaching as their occupation. The other pursuits

selected by a large number were: nursing, 18.7 per cent; homemaking, 13.6; pharmacy, 10.5; business, 10.1; dressmaking, 5.8; medicine, 3.5. A few girls selected law, chemistry, and dentistry. There were nineteen types of occupations mentioned. This number was less than that chosen by the male seniors.

Those girls not intending to pursue further instruction had a still narrower range of choice. Only nine occupational types were selected, the most important of which were: teaching, 36.0 per cent; dressmaking, 18.6; nursing, 13.4; homemaking, 13.4; and business, 13.4.

Comparison of parents' occupations and students' choice

It was found that while certain occupations included a large number of parents, they were chosen by only a relatively few male students. Similarly, certain occupations which included only a few parents were selected by a large number of seniors. There were also certain vocations in which the percentage of parents included and percentage of students choosing them were practically the same. In table 5, the different occupations are roughly classified into these three groups.

One of the occupations in the first group was farming, which included 51.1 per cent of the parents but was chosen by only 17.7 per cent of the students. The respective percentages for some of the other occupations in this group were: fisherman, 3.8 as against 0.9; employee, 3.1 as against 0.4; clerk, 3.1 as against 1.1; carpenter, 2.8 as against 1.0.

In the second group, law is a good example. While only 1.7 per cent of the parents were lawyers, 11.6 per cent of the male seniors selected it. The respective figures for other occupations are: engineering, 0.1 as against 8.0 per cent; medicine, 0.3 as against 7.3; aviation, 0 as against 5.1; chemistry, 0 as against 4.4; army, 0.6 as against 7.1; teaching, 1.4 as against 5.2; navy, 1.4 as against 3.2.

Business is a good example of those occupations falling in the third group. In business were engaged 12.8 per cent of parents. It was chosen by 10.0 per cent of the seniors. Mechanics, which included 2.1 per cent of parents, was selected by 2.9 per cent of the seniors. The other occupations which may be included in this group are tailor, policeman, accountant, minister, and contractor.

Proportion intending to follow parents' occupations

In table 6 are shown ten important occupations in which a large number of parents were engaged and the occupations chosen by their

sons. Of the 363 sons of farmers, only 93, or 25.6 per cent, selected farming. The others wanted to become lawyers, businessmen, doctors, engineers, teachers, aviators, soldiers, etc. Of the 90 sons of merchants, 18, or 20 per cent, wanted to follow their parents' occupation. The percentages for the other occupations were: fisherman, 22.2 per cent; unskilled laborer, 0 per cent; employee, 0; carpenter, 9.1; mechanic, 20.0; teacher, 10.0; lawyer, 54.5 per cent. With the exception of sons of lawyers, only a small proportion of the students wanted to follow their parents' vocations.

SUMMARY

1. The proportion of high school seniors intending to go to college was: male, 79.4 per cent; female, 73.2 per cent; both sexes. 77.5 per cent.

2. More than one-half, or 51.1 per cent, of fathers of male high school seniors were farmers and workers in agricultural pursuits. and 12.8 per cent were engaged in commerce. Only very few were in the professions.

3. While 15.1 per cent of the male seniors who intended to go to college wanted to become farmers, 14.4 per cent chose the law profession. A large number selected the following pursuits: medicine, 9.1 per cent; engineering, 9.6; business, 8.8; aviation, 5.9; army, 5.4; chemistry, 5.4; teaching, 5.1; navy, 3.5; mining and mining engineering, 3.2 per cent. Those not intending to pursue higher education selected the following occupations: farming, 27.9 per cent; business, 14.5; army, 13.3.

4. The principal choice of female seniors who intended to go to college was: teaching, 26.4 per cent; nursing, 18.7; homemaking, 13.6; pharmacy, 10.5; business, 10.1; dressmaking, 5.8; and medicine, 3.5.

5. While a large number of the pupils' fathers were engaged in certain occupations, only a small percentage of seniors selected these pursuits.

6. Except in the case of the law profession, wherein about one-half of the lawyers' sons wanted to follow in their fathers' footsteps, less than one-fourth of pupils wanted to follow the occupations of their parents. The proportion for the entire group was 21.1 per cent. In a few occupations, not one of the sons selected the work of his father.

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TABLE 1

Number of seniors studied, their sex and intention to go to college

	MALES	FEMALES	TOTAL
Number of seniors	800	351	1,151
Percentage	69.5	30.5	100.0
Intending to go to college	635	257	892
Not intending	135	79	214
Doubtful	30	15	45
Percentage intending to go to college	79.4	73.2	77.5
Percentage not intending to go to college	16.9	22.5	18.6
Percentage doubtful	3.7	4.3	3.9

TABLE 2

Occupation of parents of male students

OCCUPATION	NUMBER	PERCENTAGE
Farmer, agriculturist	363	51.1
Merchant	91	21.8
Fisherman	27	3.8
Laborer	26	3.6
Employee	22	3.1
Clerk, messenger	22	3.1
Carpenter	20	2.8
Mechanic	15	2.1
Lawyer	11	1.7
Teacher	10	1.4
Goldsmith	10	1.4
Sailor	10	1.4
Treasurer	9	1.3
Chauffeur	8	1.1
Tailor	7	1.0
Policeman	6	.8
Bookkeeper, accountant	5	.7
Soldier	4	.6
Foreman	4	.6
Justice of the peace, contractor (3 each)	6	.8
Butcher, cook, notary public, member of provincial board, physician, sanitary inspector, plumber, minister, agent, postmaster (2 each)	20	2.8
Dentist, engineer, auditor, musician, photographer, pharmacist, baker, barber, warden, laundryman, painter, railroad agent, watch repairer, telephone lineman (1 each)	14	2.0
Total	710 [a]	100.0

[a] Of the other 90, 79 reported that their parents were dead; 11 gave no answer.

TABLE 3

Occupational choice of male seniors

OCCUPATION	INTENDING TO GO TO COLLEGE		NOT INTENDING OR DOUBTFUL		TOTAL	
	number	*per cent*	*number*	*per cent*	*number*	*per cent*
Farmer, agriculturist	94	15.1	46	27.9	140	17.7
Lawyer	90	14.4	2	1.2	92	11.6
Engineer, civil, mechanical	60	9.6	3	1.8	63	8.0
Physician	57	9.1	1	.6	58	7.3
Businessman, merchant	55	8.8	24	14.5	79	10.0
Aviator	37	5.9	3	1.8	40	5.1
Chemist, industrial chemist	34	5.4	1	.6	35	4.4
Soldier	34	5.4	22	13.3	56	7.1
Teacher	32	5.1	9	5.5	41	5.2
Sailor	22	3.5	3	1.8	25	3.2
Miner, mining engineer	20	3.2	—	—	20	2.5
Forester	14	2.2	—	—	14	1.8
Mechanic, auto-repairer	12	1.9	11	6.7	23	2.9
Dentist	8	1.3	—	—	8	1.0
Painter	8	1.3	2	1.2	10	1.3
Radio operator	7	1.1	1	.6	8	1.0
Priest, minister	7	1.1	1	.6	8	1.0
Journalist, newspaperman	6	1.0	1	.6	7	.9
Architect	6	1.0	1	.6	7	.9
Clerk, stenographer	4	.6	5	3.0	9	1.1
Accountant	3	.5	—	—	3	.4
Musician	3	.5	4	2.4	7	.9
Fisherman	3	.5	4	2.4	7	.9
Carpenter	1	.2	7	4.2	8	1.0
Contractor, detective, photographer, botanist, veterinarian, librarian, policeman, chauffeur, employee	8	1.3	14	8.5	22	2.8
Total	625 [a]	100.0	165	100.0	790 [b]	100.0

[a] Out of 635, 10 gave no reply.
[b] Out of 800, 10 gave no reply.

TABLE 4

Occupational choice of female seniors

OCCUPATION	INTENDING		NOT INTENDING	
	number	*per cent*	*number*	*per cent*
Teacher	68	26.4	27	36.0
Nurse	48	18.7	10	13.4
Homemaker, housekeeper	35	13.6	10	13.4
Pharmacist	27	10.5	—	—
Merchant	26	10.1	10	13.4
Dressmaker, cutter, embroiderer	15	5.8	14	18.6
Physician	9	3.5	—	—
Lawyer	5	1.9	—	—
Chemist	5	1.9	—	—
Dentist	3	1.2	—	—
Stenographer	3	1.2	—	—
Poultry and swine raiser	3	1.2	—	—
Journalist	2	0.8	1	1.3
Accountant	2	0.8	—	—
Pianist, music teacher	2	0.8	1	1.3
Agriculturist	1	0.4	1	1.3
Soap maker	1	0.4	—	—
Interior decorator	1	0.4	—	—
Librarian	1	0.4	—	—
Beauty culturist	—	—	1	1.3
Total	257	100.0	75	100.0

TABLE 5

Classification of occupations based on proportion of parents engaged as compared to number of students selecting same

NAME OF OCCUPATION	OCCUPATION OF FATHERS		CHOICE OF SENIORS	
	number	*per cent*	*number*	*per cent*
I. Farmer	363	51.1	140	17.7
Fisherman	27	3.8	7	.9
Laborer	26	3.6	—	—
Employee	22	3.1	3	.4
Clerk	22	3.1	9	1.1
Carpenter	20	2.8	8	1.0
Goldsmith	10	1.4	—	—
Treasurer	9	1.3	—	—
Chauffeur	8	1.1	1	.1
Foreman	4	.6	—	—
Justice of the peace	3	.4	—	—
II. Lawyer	11	1.7	92	11.6
Engineer	1	.1+	63	8.0
Physician	2	.3	58	7.3
Soldier (army)	4	.6	56	7.1
Teacher	10	1.4	41	5.2
Aviator	—	—	40	5.1
Chemist	—	—	35	4.4
Sailor (navy)	10	1.4	25	3.2
Miner, mining engineer	—	—	20	2.5
Forester	—	—	14	1.8
Minister	2	.3	8	1.0
Painter	1	.1+	10	1.3
Radio operator	—	—	8	1.0
Dentist	1	.1+	8	1.0
Architect	—	—	7	.9
Journalist	—	—	7	.9
Musician	1	.1+	7	.9
III. Merchant, businessman	91	12.8	79	10.0
Mechanic	15	2.1	23	2.9
Tailor	7	1.0	6	.8
Policeman	6	.8	2	.3
Accountant	5	.7	3	.4
Contractor	3	.4	1	.1
Miscellaneous	26	3.7	9	1.1
Total	710 [a]	100.0	790 [b]	100.0

[a] Of 800, 79 reported father dead and 11 gave no answer.
[b] Of 800, 10 did not reply.

TABLE 6

Relation between fathers' occupations and sons' choice

CHILDREN'S CHOICE	OCCUPATION OF FATHER									
	Farmer	Merchant	Fisherman	Laborer	Employee	Carpenter	Clerk, messenger	Mechanic	Lawyer	Teacher
Farmer (agriculturist)	93	9	2	2	1	3	1	1	—	—
Lawyer	45	9	5	2	6	2	3	—	6	2
Physician	26	7	—	1	3	1	2	—	2	1
Engineer	26	8	—	2	3	1	1	—	—	1
Aviator	18	8	1	—	—	1	1	2	1	2
Businessman (merchant)	30	18	2	2	2	2	—	1	1	2
Soldier	18	9	—	2	—	1	—	2	—	—
Sailor	10	3	2	—	1	1	—	—	—	—
Chemist	13	2	—	1	—	2	4	3	—	—
Teacher	19	3	4	1	1	1	1	1	—	1
Miner	8	6	—	1	1	—	—	—	1	—
Forester	7	—	2	1	—	—	1	—	—	—
Fisherman	1	—	6	—	—	—	—	—	—	—
Mechanic	5	1	—	—	—	—	—	3	—	—
Dentist	4	—	—	—	—	—	—	1	—	1
Architect	4	—	—	1	1	—	—	—	—	—
Carpenter	4	—	1	—	—	—	—	—	—	—
Clerk	1	—	—	—	—	3	2	—	—	—
Miscellaneous	31	8	2	10	3	2	6	1	—	—
Total	363	91	27	26	22	20	22	15	11	10
Per cent selecting fathers' occupation	25.6	19.8	22.2	0	0	0	9.1	20.0	54.5	10.0

STUDIES ON THE BREEDING HABITS OF CATTLE [1]

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Of the Department of Animal Husbandry

Records of the Department of Animal Husbandry, College of Agriculture, University of the Philippines, bear out the common observation that some cows are more prolific than others. Some produce a calf almost every year, while others, at considerably long intervals. Large animals are very expensive to maintain, and when they do not reproduce regularly, they are liabilities on the farm. It is important, then, to determine what factors affect the intervals between calvings, and which of these may be controlled.

Object of the work

These studies were undertaken with the object of answering the following question:

1. How long after calving does it take cows to come in heat?
2. How many services do the cows require (*a*) at the first oestrus and (*b*) at each succeeding oestrus?
3. What is the percentage of cows that do not conceive following service during the first and the succeeding oestrous periods after parturition?
4. What factors, physiological or otherwise, that interfere with successful impregnation at each heat period are present in the cows?
5. To what extent do the seasons, dry and rainy, affect the recurrence of oestrus?
6. Is milking a factor in the duration of intervals between calvings?
7. In cows of breeding age, are younger ones more prolific than older ones?

MATERIALS AND METHODS

All the cows and heifers in the breeding and dairy herds of the Department of Animal Husbandry were made available for these

[1] The greater part of the data in this paper were contained in a thesis presented by the junior author for graduation in March, 1933, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, No. 848; Experiment Station contribution No. 1215. The thesis was prepared under the direction of the senior author.

studies. Daily observations were made on the animals for a period of twenty-five months, namely, from April 1, 1931, to April 30, 1933. The cows and heifers were divided into three groups of even numbers designated as groups 1, 2, and 3. The average ages of the animals are 3½ years for group 1, 7½ years for group 2, and 11 years for group 3.

Every day (seven times a week) throughout the duration of the experiment, from 5:00 to 7:00 a.m., and from 5:00 to 6:30 p.m. and for a longer time when necessary, a bull of known fertility was taken to the pastures where the cows were herded. Complete records of the condition and behavior of the cows were made. The bull was turned loose in the pasture and allowed to stay with the cows until the observer was satisfied that no cows were in heat. Since there were two pastures where observations were made daily, the bull was taken from one pasture to another. If a cow was in heat and mating took place, a record was made of her behavior both before and after the service. The symptoms given particular attention were: restlessness, number of times the bull approached the female, the manner in which the cow carried her tail (whether raised or not when approached), the appearance of the external genitals, behavior of the female such as mounting other animals, urinating in the presence of the bull, the presence of mucoid discharges from the genitals, changes in condition of the udder, the behavior of the cow on meeting the bull, the appetite of the cow, condition and color of the vaginal mucosa both before and after mating.

Vaginal smears

After each successful mating, smears from the vagina were taken for microscopic examination. In case a cow refused the service, even though she showed symptoms of heat, her behavior and reaction towards the bull were observed from a secluded place where the observer could not readily be seen by the animals. Vaginal smears were also taken in such cases, and cows which had not exhibited symptoms of heat three months or more after calving were treated in the same manner.

The smears were obtained soon after mating. After properly restraining the animal, a clean spoon specially made for the purpose was used to scrape material from the walls of the vagina. Thin smears of these scrapings were made on clean slides. The smears were air dried, stained with methylene blue, then washed

in distilled water. Microscopic examinations were made after the slides had dried.

In some cases, as for example, if two or more cows had shown signs of oestrus, vaginal smears were taken in the pastures instead of driving the animals into a corral. This was done by driving the cow into the salting house in the pasture and restraining it with ropes. Camera lucida drawings were made of the typical pictures of the vaginal smears in an effort to determine whether the vaginal mucosa showed a characteristic histology during the oestrous period.

Pregnancy and parturition

Such early symptoms of pregnancy as condition of the animal, appearance of the external genitals and udder, enlargement of the abdomen and other parts that change in this condition were given particular attention in the hope of finding reliable symptoms of pregnancy as early as possible. All observations were carried up to the time of parturition. Such changes in the cow as the appearance of the hair, presence of blood, prominence of the sacrum, deepening of the coccygeus, prominence of the tuber ischii, deepening of the lumbo-sacral articulation, straightening of the back, form of the abdomen, and condition of the udder were given particular attention. The mother and calf were weighed as soon as possible after birth. They were then quartered for three days in the barn. On the day following parturition, vaginal smears were secured in the same manner as before. Observations on the color of the vaginal mucosa were also made.

The junior author took charge of the bull. When not with the cows, the bull was tethered in nearby pastures separate from other animals. He was kept under shade during the hotter part of the day and in the barn during rainy days. In good weather, he was tethered in the open pasture after sundown.

The cows in the dairy herd were run in two sets; one set was milked in the forenoon, and the other in the afternoon. These cows were not fully milked as their calves were allowed to run with their mothers. Both sets were taken to the barn between 6:00 and 7:00 a.m. Before milking, they were placed in the stanchions where they were watered. Each animal was given about one kilogram of a grain feed mixture consisting of rice bran, 30 parts; copra meal, 5 parts; and corn, 10 parts. The cows were all cleaned before they were milked. After milking, each animal was given about 12 kgm. of silage. Between 8:30 and 9:30 a.m., the herd was confined in

the home corral near the dairy barn. At 1:00 p.m., those cows that were to be milked in the afternoon were placed in stanchions, thoroughly cleaned, and milked. At about 3:00 p.m., when milking was completed, the cows were driven to the pastures where they grazed and passed the night. These pastures were properly subdivided for purposes of rotation.

The animals in the breeding herd were kept in separate pastures. Animals that were released from the dairy herd were put in the breeding herd. The pastures for the breeding herd were subdivided to follow the same procedure of rotation as that for the dairy herd. Each division was so arranged as to give the animals access to the creek where good drinking water was available at all times. A supply of salt was available in the salting house for all divisions.

RESULTS AND DISCUSSION

Seasonal occurrence of oestrus

In reporting the data of successful matings among cattle in the College of Agriculture from 1920 to 1929, Villegas (1929) stated that the cows were observed to be sexually active throughout the entire year. In general, the data obtained in the present studies are in agreement with those reported by Villegas. It was found, however, that a relatively smaller number of heifers and cows took the bull or were bred during the months of April, May, and June than at other months of the year. These months coincide with the hot or dry season in Los Baños. Citing Wallace, Marshall (1922) states that in temperate countries the recurrence of oestrus is oftener in summer than in winter. Those who are unacquainted with conditions in the tropics may be led to believe that temperature is the most important factor concerned in the occurrence of oestrus. In the present studies, however, a low feed supply apparently exerts a more depressive influence than temperature on the recurrence of oestrus. During the months of April and May, the pastures in the College of Agriculture are invariably very poor, the grass being fairly dry, while in June the grass is just beginning to grow. In these months, range cattle lose weight and become poor in condition. That the reproductive ability of cattle is associated with the plane of nutrition of the animals is borne out by the observation of Hart and Guilbert (1928), who state that feed has an important bearing in the development of oestrus. In temperate countries, the reverse is true, that is, pasture grasses are more abundant in the summer months, and it is during summer that breeding is most active, apparently due less to temperature than to abundance of feed.

Symptoms of oestrus

The observations made on the cows at the time the bull was brought to them are grouped under the following topics: (1) restlessness, (2) number of times approached by the bull, (3) isolation from the main herd, (4) mounting other animals, (5) passing water when approached by the bull, (6) condition of the external genitals and mammary glands, (7) appetite, (8) and carriage of the tail. Such symptoms as urination, separating from the main herd, drooping of the lumbo-sacral articulation, all of which have been reported by some workers on the subject (Murphey, 1925), were not observed with regularity. It was the exception rather than the rule for cows which were in heat to pass water when approached by the bull. Great restlessness at or before the time of mating was found to be rather regular in its appearance. Very few cows isolated themselves from the main herd when they came in heat. Enlargement of either the external genitals or the mammary glands was not correlated with the occurrence of oestrus. However, the concurrent enlargement of these two organs during the time of oestrus was invariably accompanied by other symptoms of heat, such as, restlessness, raising of the tail, and passing of urine in small quantities.

The carriage of the tail was found to be a very reliable symptom of heat, the tail head being raised before service and held in that position for several hours after service. After mating, the top line of the animal was usually arched.

Only about two-thirds of the heifers which exhibited signs of oestrus took the bull immediately. Of the remaining one-third, some were served later, but there were a few which were not served at all. One cow was noticed to show all the symptoms of oestrus in the morning on January 20, 1932, but was not served until late in the afternoon. In another cow the symptoms of heat were very evident on April 2, 1933. Service did not take place until two days later. In a third cow it took eight days from the time she was observed in oestrus until she was served. Harper (1914) and Mumford (1926) point out that the duration of heat in cows is from 12 to 24 hours, and Hammond (1925a) states that the duration is longer in summer than in winter and that some individuals show shorter periods than others. The data obtained in the present studies indicate that a similar condition obtains among cows in the Philippines and that cows might have accepted the bull had he been with the herd earlier or been left with the cows for a longer period. The

need of keeping a bull with breeding cows at all times is quite apparent from this observation, if the highest breeding efficiency is to be obtained.

Color of vaginal mucosa

The variations in color and pigmentation of the vaginal mucosa in open heifers and cows have been studied by the senior author (1931). In this study, the color of the mucosa of healthy individuals was designated as roseate. A deeper tinge of red than roseate was called red, and if the redness turned darkish, it was designated as dark red. A lighter shade than red was called pale. Pale mucous membrane with yellowish discoloration was called icteric. In the present study, of the 38 cows that came in heat and actually accepted the bull, 31 exhibited a dark red color of the vaginal mucosa; six were roseate; and one was pale. Of the 15 cows that came in heat but refused service, only six had a dark red color; nine were roseate. It is evident from these data that the vaginal mucosa becomes congested at the oestrous period. However, there were females which had dark red mucosa but did not accept service. The sexual excitement undoubtedly is accompanied by an increase of blood supply in the genital organs, but this may not always be visible in the mucosa of the vagina. It may be stated that, with closely confined animals, the appearance of dark red coloration of the vaginal mucosa, if accompanied by other symptoms of oestrus, is a very good sign that mating will occur.

Symptoms of pregnancy

The weights of the pregnant animals taken on the day they were mated, and every month thereafter up to the time of parturition, as well as the symptoms shown by the cows during pregnancy, are given in table I. It may be seen in the table that during the first six months of pregnancy no appreciable increment in the weights of the cows was discernable. In general, the increase in weight incident to pregnancy began on the seventh month and followed a regular ascending curve up to the time of calving. However, individual exceptions have been observed. For example, two cows, Nos. 78 and 110 in the table, showed marked increase in weight between the fourth and fifth months of pregnancy but suffered a set-back between the sixth and seventh months, after which they resumed regular ascending weight curve.

One of the most common symptoms of pregnancy noted was the improvement in the condition of the animal, which became quite marked as early as the fifth month in some cows and as late as the

eighth month in others. Harper (1914) states that fattening at the early stages of gestation is one of the most reliable symptoms of pregnancy. It was noticed that some cows increased in weight without appearing to get fatter. Neither is the enlargement of the abdomen always accompanied by increase in weight. Marked enlargement of the abdomen caused by a developing foetus was first noticed as early as 118 days, or about four months, and as late as the eighth month, 243 days, after impregnation. In some cows prominent abdominal enlargement was observed rather early, but in the majority this symptom became manifest only from the sixth to the eighth month. According to Harper, the swelling of the external genitals alone is not a reliable indication of pregnancy. The observation that pregnant cows are clumsy and incapable of performing certain movements is more valuable. In the present study, the swelling of the genitals was observed as early as the fourth month in some cases; in others, it was not observed until a few days before the delivery of the young, but it was more commonly observed from the sixth month of pregnancy.

Enlargement of the mammary glands was observed as early as 5½ months, or 167 days after impregnation. In heifers this symptom appeared early; in older cows the udder did not become greatly distended until a few days before parturition. This observation is in agreement with those of other workers such as Hammond (1925a) and Rice (1926). Nibbler and Turner (1929) found great variability in the size and degree of development of the mammary glands and attributed this variability to individual characteristics.

Drooping of the rump was observed as early as the sixth month, or 188 days, and as late as the ninth month, or close to the time of calving. There were cases in which the sinking of the rump occurred as late as the eighth month after impregnation; in others, in the seventh month. In general, this symptom was observed in the later stages of pregnancy. Sagging of the back is another symptom found valuable in diagnosing pregnancy. In old cows this symptom appears as early as the sixth month of pregnancy and indicates normal development of the foetus.

However, in cows having a natural sway back not much reliance can be put upon this symptom.

Mucoid secretions from the genitals, described by Harper (1914) as ropy mucus, were first noticed as early as 147 days and as late as 283 days. In some cows the mucoid discharges were quite profuse. This ropy mucus persists for a long time, turning dark brown in color when old.

The presence of heat, generally reported by animal breeders to cease during the period of pregnancy, was observed in a number of cows definitely known to be pregnant. This is in agreement with the observation of Harper (1914), who states that occasionally cows may accept the bull even in the advanced stages of pregnancy.

The coming of parturition

Early recognition of the symptoms of approaching parturition is important in that it enables caretakers to pay particular attention to such animals and prepare for the event. Table 2 gives in summary form the principal symptoms of approaching parturition observed. The time in days when the symptoms of pregnancy are further developed is also shown in the table. It will be noted that a wide variability exists in the time of appearance of the different symptoms. For example, the external genitals do not become markedly enlarged until sixteen to three days before calving. This increase in size of the parts may not necessarily mean distension of the organ, for in some cases the parts show only flabbiness. And it is not only the organ that is enlarged but also the surrounding parts. There is not always a corresponding increase in size or distention of the udder with further enlargement of the genitals. A case was observed (Georgia, in the table) in which the genitals increased in size fifteen days before calving, while the mammary glands were not greatly distended until three days before calving. Another case (Esther) presented enlarged genitals sixteen days before, while the udder increased only seven days before calving. Rebecca showed this symptom twelve days before calving while her udder was not markedly distended until just five days before calving. Other cows whose mammary glands were well distended at the same time the genitals became enlarged were observed. The enlargement of the mammary glands and the genitals may be observed as early as two to three weeks and as late as three days before calving.

Further depression of the rump is an important indication because, as the mother prepares for the approaching parturition, the muscles of the rump relax causing them to sink. According to Mumford (1926), this sinking is due to the softening of the muscles, which facilitates the passage of the young through the canal of the pelvis. It was noted in the present study that when a depression appeared on each side of the sacrum at the base of the tail, the cow generally dropped her calf within a few days. A similar observa-

tion was reported by Marshall and Hammond (1926). It may be seen in the table that the depression of the rump and the deepening of the lumbo-sacral articulation generally appeared at about the same time. Mucoid secretions from the genitals appeared from twenty-two days to five days before parturition. Shortly before parturition the teats fill out to the tips and milk may escape in drops. Mumford claims that much reliance can be placed on this symptom because the young is born within twenty-four hours after wax forms on the teats. Uneasiness, switching of the tail, lying down and then rising, and lowing are reliable indications that labor pains have begun.

Observations after parturition

As the majority of the cows under study dropped their calves during the night, it was not possible to record the behavior exhibited by all the animals at the time of calving. It was found that most of the cows kept under range conditions separated from the herd at the approach of parturition, hiding their calves for a time. Some observers claim that this is done for psychological reasons. We have been able to make observations on some of these cows and found that during such times the mother licks her calf clean. After that she lets it rest. In some cases the cow joins the herd, leaving her calf hidden in the bush.

The symptoms shown by the cows within twenty-four hours after calving are summarized in table 3. In these cows the external genitals appeared slightly or greatly reduced in size, and except in a very few cases, showed no blood stains. The placenta was generally passed out immediately after calving. There were a few cases, however, in which the afterbirth persisted; three cases were found in which the placenta was still retained on the day following parturition. The sacrum was very prominent and spare. The coccygeus and the muscles on both sides of the sacrum became more depressed. The pin bones, which as a rule are rounded and full, became lean and prominent. The lumbo-sacral articulation was further depressed. The topline was straight except in two cases; one showed an arched back, the other a slightly swayed back.

Examination of the vaginal mucosa at parturition revealed that, of the eleven cases observed, only one case was pale, three were roseate, and seven dark red. Because of lack of uniformity in the appearance of the vaginal mucosa, its color can not be used in diagnosing the approach of parturition.

The recurrence of oestrus, breeding efficiency, and gestation period

It may be seen in table 4 that the interval between calvings and the first appearance of oestrus varied from 10 days to 234 days, the average being 107.84 days. The early or late recurrence of oestrus after calving appeared to be an individual characteristic rather than one of the groups of heifers and cows. That the plane of nutrition does not necessarily influence this physiological function is shown by the breeding history of two cows, Cora and Luz. The former calved on July 21, 1931, the latter, on August 9, 1931, both months being favorable as to weather conditions as well as feed, and presumably for breeding; but both these cows required nearly seven months before they could be bred. Wright (1923) states that when mothers nurse their calves, they do not come in heat early. In this study, cows similarly treated and calving in the same month differed greatly as to the time of recurrence of heat.

It is apparent from the data shown in table 4 that pregnancy does not always follow after the first service. There were cows which did not become pregnant until the third oestrus, although these were bred at least once during each oestrus. According to Miller, Swett, Hartman and Lewis (1931), oestrus may not necessarily be accompanied by ovulation, but this question is still controversial (Marshall, 1931).

The breeding efficiency computed from the data in table 4 shows that out of a total of 19 matings only 12 were followed by pregnancy, thus making the efficiency about 63 per cent. This is in agreement with the finding of Gowen and Dove (1931). Of a total of 7,679 cows they reported, only 64 per cent became impregnated after the first service. A much higher percentage of those cows, however, which did not become pregnant after the first breeding conceived on subsequent matings. The cause of the low percentage of successful matings among cattle has been attributed by different investigators to both the cows and the bulls. According to Miller, Swett, Hartman, and Lewis (1931), the cows are to be blamed because some of them do not ovulate at the proper time for impregnation. The present studies do not shed any light on the cause of the failure of some cows to conceive, but they exclude the possibility of attributing it to the male, inasmuch as the bull used was known to be highly fertile.

The duration of the oestrous cycle in cattle has been reported by a number of investigators as being twenty-one days (Rice, 1926; Mumford, 1926; and Hammond, 1925a), the range of variation being from 16 to 24 days. In the present studies the average interval

between heat was found to be 20 days, with the range at from 11 to 23 days. With the data secured from a relatively few animals, it may be said that there is close agreement between these data and those reported by other investigators.

All available data in the Department of Animal Husbandry, College of Agriculture, show that the duration of the gestation period ranged from 269 to 300 days, the average being 284 days. Rice (1926) stated that the duration of pregnancy in cows is 281 days, or approximately 9 months. Harper (1914), Marshall and Hammond (1926) reported a similar figure, namely, 280 days, the range being from 240 to 321 days. Rommel (1924) and Wright (1923) reported 283 days. The average found in the present studies is, therefore, in close agreement with those obtained from cattle in other countries.

Intervals between calving and the first appearance of oestrus

In view of the fact that some cows do not come in heat for a long time after calving while others come early, it seems important to learn whether milking the cows exerts any effect on their breeding efficiency. It may be seen in table 5 that some cows which were milked regularly conceived when bred after short rest periods, while in the case of others the time interval was much longer before they could be successfully mated. For example, the cow Shine dropped her calf on May 16, 1931. Seventy-three days later, she was bred but did not catch until after a second mating 92 days after calving. From this time up to January, 1932, she was milked regularly and was not released from the milking herd until she was advanced in pregnancy. When she dropped her calf on May 23, 1932, she was not milked. The first oestrus did not appear until 83 days after calving, and she was not successfully bred until 122 days after calving.

The cow Priscilla was not milked at all from April, 1931, to August, 1932. She dropped a calf on April 20, 1931, and became pregnant when mated at the occurrence of oestrus 21 days after calving. She dropped another calf on February 25, 1932, but this time she did not conceive until 141 days after calving. Cow No. 110, Rebecca, which was not milked regularly, calved on March 25, 1931, and exhibited the symptoms of heat 147 days after calving. She calved again on May 14, 1932, but oestrus did not appear until 234 days after calving. The average interval between calving and successful impregnation in this cow was 190 days. Other cases of similar nature have been observed in the present studies, thus mak-

ing it apparent that milking the cows does not affect the regularity of breeding. It appears likely that the physical condition and individual characteristic of the animals are more important factors than milking in determining their fitness for reproduction.

Age at first calving and interval between calvings

Whether the age at first calving has any relation to the interval between calves is an important point in breeding operations. A study of the progeny performance of all cows of the Department of Animal Husbandry, College of Agriculture, shows that the age at first calving can not be taken as an index of the prolificacy of the cow. According to Villegas (1929), a yearly calf should be expected from the cows, and failure to produce one calf every two years should be sufficient reason for culling a cow out of the breeding herd. The intervals between calving found in the present studies ranged from 11.54 to 19.85 months, the average being 14.26 months or about 430 days. This finding agrees closely with the data reported by Villegas in earlier studies that the interval between calvings is about 12 months.

Vaginal smears examined

Long and Evans (1922) claim to have established the fact that in the rat the epithelium of the vagina comes to acquire a characteristic histology detectable from vaginal smears, which can be used to determine precisely the stage in the period of the oestrus cycle. The senior author (1931), working with cattle, stated that vaginal smears can not be used in diagnosing the occurrence of oestrus. His work, however, was carried on only for a short time and on range animals. So it was thought worthwhile to repeat the work for a longer period on animals closely confined. In the previous study, two or possibly three types of cells were found in the vaginal mucosa of cattle: namely, desquamated epithelial cells, leucocytes, and a third type, tentatively designated as cornified cells. The epithelial are nucleated, irregularly shaped cells varying in size from about 33 to 50 micra. The leucocytes are mostly polymorphonuclear. The cornified cells are large, irregularly shaped, devoid of nuclei or having very indistinct nuclei in the substance of a faintly staining protoplasm. They differ from the epithelial cells in that they are very much larger. Under stained preparations, these cornified cells may be numerous, few, or entirely absent.

Of 36 cows that were mated and from which smears were taken, 21 showed all the three types of cells, namely, epithelial, cornified,

and leucocytes; 11 showed epithelial and cornified cells only; and 2 showed epithelial cells only.

Of 14 animals that were in heat but did not accept the bull, 8 showed all the three types of cells; 5, epithelial and cornified cells only; and one, epithelial cells only.

Smears taken from animals that were not in heat showed the following distribution of types of cells: Of the 20 cases studied, 6 showed all the three types of cells; 11, epithelial and cornified cells only; and 3, epithelial cells only.

Of the 12 vaginal smears taken on the day following parturition, 11 showed all the three types of cells and one, epithelial and cornified cells only.

It is evident from the foregoing data that the vaginal mucosa of cows does not acquire a characteristic histology discernible through smears that would enable one to tell whether an animal is in the stage of oestrus or anoestrus.

SUMMARY AND CONCLUSIONS

1. The cows under study exhibited the phenomenon of oestrus throughout the year. In the months of April, May, and June, generally considered summer months in this country, the occurrence of oestrus was less frequent than during any other three consecutive months.

2. The symptoms of oestrus are many. The most important ones are: (*a*) restlessness, (*b*) jumping over other animals, (*c*) enlargement of the external genitals and congestion of the vaginal mucosa, (*d*) presence of the mucoid discharges from the vagina, (*e*) loss of appetite, (*f*) arched back, and (*g*) elevation of the tail when approached by a bull. The dark red discoloration of the vaginal mucosa when observed without unduly exciting the cow, if present with other symptoms of oestrus, was found to be a very good indication of its occurrence.

3. The duration of heat in the cow is usually short; in some cases, however, it may last several days. For this reason, the breeding bull should be kept in the breeding herd in order to secure a high percentage of reproductive efficiency.

4. The symptoms of pregnancy are: (*a*) improvement of the condition of the animal discernible in some cases as early as the fifth month of pregnancy, in others as late as the eighth month, (*b*) enlargement of the abdomen which becomes quite marked from the sixth to the eighth month of pregnancy, (*c*) swelling of the external ge-

nitals, (*d*) enlargement of the mammary glands, appearing early in heifers, but not so apparent until a few days before parturition in older cows, (*e*) drooping of the rump, which is frequently observed in the later stages of pregnancy, (*f*) sagging of the back discernible as early as the sixth month and as late as the ninth months, (*g*) appearance of a ropy mucoid discharge from the orifice, usually as as early as the fifth month of pregnancy, but sometimes just a few days before parturition.

5. At the coming of parturition, the symptoms of pregnancy that were more markedly developed were: the external genitals and both udders became greatly distended from the sixteenth to the third day before calving. When a depression appeared on the muscles on each side of the sacrum down to the base of the tail, the cow generally dropped her calf within a few days. The sinking of the lumbo-sacral articulation generally occurred at the same time that further depression of the rump was noted. At such times the cows become gentle, even those generally aggressive become approachable. Mucoid secretions were not observed in most cases. In animals which showed these secretions, delivery followed within five to twenty days. The symptoms most regularly observed at the initiation of parturition were: further depression of the rump, distension of the mammary glands, including the surrounding parts of the udder, and marked swelling of the external genitals.

6. The indications discernible in cows soon after parturition were: (*a*) the genitals slightly or greatly decreased in size, with no evidence of blood, as a rule, (*b*) spare appearance of the sacrum brought about by the shrinking of the muscles on both sides of the sacrum, (*c*) tuber ischii becomes prominent, (*d*) lumbo-sacral articulation are greatly depressed, (*e*) the topline becoming level and the spinal vertebrae prominent (*f*) reduced size of the abdomen, and (*g*) acute distension of the udder except in some cases when the calf was able to suckle immediately after birth.

7. The duration of the period of gestation varied from 269 to 300 days, the average being 284 days. This average conforms with that observed in other countries.

8. The appearance of oestrus after calving varied from 10 to 234 days, the average being about 108 days. The average duration of the oestrous cycle was found to be twenty days.

9. The cow, as a rule, accepted only one service during each heat period; in rare cases two services, but not more, took place. The services were not always followed by pregnancy so that the

breeding efficiency in the present studies was about 63 per cent at first mating. This figure rose with subsequent matings.

10. Milking the cows did not markedly affect their breeding efficiency.

11. Calves were dropped throughout the year, but some cows dropped their young oftener in certain months than in others. Prolificacy in the cows studied appeared to be largely an individual rather than a group characteristic.

12. The vaginal mucosa of the cows studied did not acquire a characteristic histology that would enable one to ascertain the stage in the reproductive cycle being undergone by an animal.

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TABLE 1

Showing symptoms of pregnancy

COWS		DATE OF BREEDING	MONTHLY WEIGHT DURING PREGNANCY								
Name	Herd number		First (weight after breeding)	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Last weight before calving
			kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
Priscilla	96	May 11, '31	360.00	386.36	364.55	380.91	397.27	409.09	410.91	431.82	433.64
Shine	88	Aug. 16, '31	343.64	348.18	349.09	340.91	360.00	349.09	340.91	345.00	354.55
Rebecca	110	Aug. 19, '31	360.00	377.27	368.18	368.18	435.45	385.45	404.55	408.18	445.45
Esther	2	Aug. 27, '31	537.27	536.36	540.00	562.73	544.09	589.09	610.91	618.18	627.27
Independence	58	Dec. 21, '31	361.82	381.82	375.45	577.27	352.73	375.45	*a*	406.36	389.09
Elisa	78	Dec. 31, '31	359.09	355.45	355.45	381.82	315.45	340.00	345.45	361.82	379.09
Caroline	121	Jan. 20, '32	334.55	349.09	338.18	338.64	336.36	340.91	357.27	340.91	354.55
Elsie	151	Jan. 30, '32	304.55	295.00	323.64	318.18	320.00	324.55	340.91	337.27	341.82
Georgia	190	Feb. 14, '32	242.73	246.36	227.27	253.64	266.36	273.64	271.82	254.55	282.73
Luz	130	Feb. 16, '32	331.82	310.00	305.45	304.54	432.73	309.09	318.18	389.09	304.09
Gummamela .	62	Feb. 25, '32	360.00	370.91	331.82	355.45	324.55	361.82	365.45	385.91	403.64
Priscilla	96	July 12, '32	316.36	363.64	356.36	382 73	340.00	336.36	364.55	*b*	377.27

[a] Weight not taken because the animal was ill during this month.
[b] In the Manila Carnival Livestock Exhibits.

TABLE 1 (continued)

COWS		STAGE OF GESTATION WHEN SYMPTOMS OF PREGNANCY WERE OBSERVED					
Name	Herd number	Marked enlargement of abdomen noticeable on	Swelling of vulva noticeable on	Enlargement of udder noticeable on	Dropping of the rump noticed on	Sagging of the back noticed on	Time when mucoid secretions from vulva appeared
		day	*day*	*day*	*day*	*day*	*day*
Priscilla	96	243	243	283	283	283	283
Shine	88	216	260	260	256	256	247
Rebecca	110	118	118	183	226	226	226
Esther	2	218	218	265	218	218	Not seen
Independence ..	58	124	233	275	212	212	147
Elisa	78	199	199	199	199	199	Not seen
Caroline	121	213	258	272	272	247	Not seen
Elsie	151	238	246	246	270	246	268
Georgia	190	167	188	167	188	188	Not seen
Luz	130	152	152	210	210	210	Not seen
Gummamela ...	62	238	238	238	258	258	Not seen
Priscilla	96	187	270	280	270	233	Not seen

TABLE 2

Showing indications of approaching parturition

NAMES OF COWS	GESTATION PERIOD	STAGE OF GESTATION WHEN INDICATIONS OF APPROACHING PARTURITION WERE OBSERVED						DATE OF CALVING
		Further enlargement of vulva apparent on	Marked distention of mammary glands observed on	Further lowering of the rump marked on	Deepening of lumbosacral articulation very noticeable on	Disposition (motherliness)	Presence of mucoid secretions in the vulva seen on	
	day	*day*	*day*	*day*	*day*		*day*	
Priscilla	288	283	283	283	283	Throughout	283	February 23, 1932
Shine	281	273	273	260	260	”	274	May 23, 1932
Rebecca	269	257	264	255	255	”	255	May 14, 1932
Esther	279	263	272	263	263	’	Not seen	June 1, 1932
Independence .	287	284	284	284	Not well marked	’	265	October 13, 1932
Elisa	279	273	273	275	275	”	Not seen	October 5, 1932
Caroline	277	272	272	272	272	”	Not seen	October 23, 1932
Elsie	283	270	270	276	276	”	Not seen	November 8, 1932
Georgia	300	235	297	285	285	”	Not seen	December 10, 1932
Luz	294	288	288	288	288	”	Not seen	December 6, 1932
Gummamela ..	291	288	288	288	288	”	Not seen	December 12, 1932
Priscilla	286	280	280	280	280	”	Not seen	April 24, 1932

TABLE 3

Showing observation 24 hours after parturition

NAMES OF COWS	HUNGER HOLLOW	CONDITION OF COAT	APPEARANCE OF VULVA	PRESENCE OF BLOOD IN THE VULVA	PRESENCE OF AFTER-BIRTH IN THE VULVA	PROMINENCE OF SACRUM	DEEPENING OF COCCYGEUS
Priscilla	Deep	Glossy	Swelling decreased	None	Still hanging	Spare	Deep
Shine	Deep	Lustherless	Not swollen	None	None	Spare	Deep
Rebecca	Deep	Glossy	Slightly swollen	None	None	Spare	Deep
Esther	Deep	Glossy	Slightly swollen	Blood present in drops	None	Spare	Deep
Independence	Deep	Lusterless	Slightly swollen	None	None	Spare	Deep
Elisa	Deep	Lusterless	Swollen	None	None	Spare	Deep
Caroline	Deep	Lusterless	Slightly swollen	None	None	Spare	Deep
Elsie	Deep	Lusterless	Slightly swollen	None	None	Spare	Deep
Georgia	Deep	Lusterless	Slightly swollen	None	None	Spare	Deep
Luz	Deep	Lusterless	Slightly swollen	None	None	Spare	Deep
Gummamela	Deep	Glossy	Not swollen	None	Still hanging	Slightly spare	Deep
Priscilla	Deep	Glossy	Slightly swollen	None	Still hanging	Spare	Deep

TABLE 3 (Continued)

NAMES OF COWS	PROMINENCE OF TUBER ISCHII	DEEPENING OF LUMBO-SACRAL ARTICULATION	POSITION OF BACK	CONDITION OF ABDOMEN	CONDITION OF UDDER	APPEARANCE OF VAGINAL MUCOSA		
						Red	Roseate	Pale
Priscilla	Very prominent	Depressed	Straight (lean)	Not distended	Marked increase	*a*	*a*	*a*
Shine	Very prominent	Depressed	Straight (lean)	Not distended	Marked increase			Pale
Rebecca	Very prominent	Depressed	Straight (lean)	Not distended	Markedly distended	Dark red		
Esther	Very prominent	Slightly depressed	Straight	Not distended	Markedly distended	Dark red		
Independence	Very prominent	Depressed	Straight (lean)	Not distended	Markedly distended	Dark red		
Elisa	Very prominent	Depressed	Straight (lean)	Not distended	Markedly distended	Dark red		
Caroline	Very prominent	Depressed	Straight (lean)	Not distended	Markedly distended		Roseate	
Elsie	Very prominent	Depressed	Straight (lean)	Not distended	Marked increase		Roseate	
Georgia	Very prominent	Depressed	Arched back	Not distended	Markedly distended	Dark red		
Luz	Very prominent	Depressed	Straight	Not distended	Markedly distended	Dark red		
Gummamela	Very prominent	Depressed	Slightly swayed	Not distended	Not fully distended	Dark red	Roseate	
Priscilla	Prominent	Depressed	Straight (lean)	Not distended	Well distended			

TABLE 4

Showing the interval between calving and first heat, interval between oestri, and number of services rendered during each heat period before pregnancy

NAMES OF COWS	DATE OF CALVING	INTERVAL BETWEEN CALVING, AND FIRST HEAT	INTERVAL BETWEEN OESTRI	NUMBER OF SERVICES		
				First heat	Second heat	Third heat
Priscilla	April 20, '31	10	11	1 time	1 time	
	Feb. 23, '32	141	—	2 times		
Shine	May 16, '31	73	19	1 time	2 times	
	May 23, '32	83	39	2 times	1 time	
Rebecca	March 25, '31	147	—	1 time		
	May 14, '32	234	—	2 times		
Esther	June 1, '32	61	—	1 time		
Independence	Aug. 16, '31	50	23	1 time	[a]	1 time
	Oct. 13, '32	37	64	2 times		
Elisa	Sept. 22, '31	60	40	1 time	1 time	
	Oct. 5, '32	57	—	1 time		
Caroline	Dec. 16, '31	35	—	1 time		
	Oct. 23, '32	46	—	2 times		
Elsie	June 29, '31	.215	—	1 time		
Georgia	Dec. 10, '32	[b]	19	2 times	2 times	
Luz	Aug. 9, '31	191	—	1 times		
	Dec. 6, '32	107	—	2 times		
Gummamela	Aug. 13, '31	196	—	2 times		
Cora	July 21, '31	227	—	1 time		
Venus	Oct. 2, '31	79	—	1 time		

[a] Oestrus occurred on October 28, 1931, constituting the second appearance of oestrus which was purposely missed because the animal was bred to another bull at the third oestrus.

[b] Virgin heifer

TABLE 5

Showing interval between calving and first oestrus and between calving to impregnation among cows (A) that were milked and (B) that were not milked

Group (A)					
NAMES OF COWS	DATE OF CALVINGS		INTERVAL BETWEEN CALVING AND FIRST HEAT	INTERVAL BETWEEN OESTRI	INTERVAL BETWEEN CALVING TO IMPREGNATION
Shine	May	16, 1931	73	19	92
Rebecca	March	25, 1931	147	—	147
	May	14, 1932	234	—	234
Elisa	October	5, 1932	57	—	57
Caroline	December	16, 1931	35	—	35
	October	23, 1932	46	—	46
Amara	January	16, 1932	192	—	192
Independence	August	16, 1931	50	53	83
	October	13, 1932	57	64	121

Group (B)					
NAMES OF COWS	DATE OF CALVINGS		INTERVAL BETWEEN CALVING AND FIRST HEAT	INTERVAL BETWEEN OESTRI	INTERVAL BETWEEN CALVING TO IMPREGNATION
Priscilla	April	20, 1931	10	11	21
	February	23, 1932	141	—	141
Shine	May	23, 1932	83	39	122
Elisa	September	22, 1931	60	40	100
Luz	August	9, 1931	191	—	191
	December	6, 1932	107	—	107
Elsie	June	29, 1931	215	—	215
Gummamela	August	13, 1931	196	—	196

SELF-FEEDING VS. HAND-FEEDING THE RATION MIXTURES USED IN THE COLLEGE OF AGRICULTURE FOR GROWING AND FATTENING PIGS [1]

BENJAMIN O. ELEAZAR

In raising pigs for the market one important object is to get them ready for slaughter with the lowest expenditure of feed, labor, and attention. A self-feeder is a simple device the use of which involves little labor. In it a supply of grain and other feeds is kept available to the hogs so that they may at any time satisfy the craving of their appetites both as to the nature and the quantity of feed. The use of self-feeders for growing and fattening hogs is gaining in popularity in the United States. In the Philippines, this system of hog feeding is not practised. An advantage, besides saving of work that is claimed for self-feeding, is that the pigs may eat at the time when they need most feed for nourishment.

No local experiment has been conducted to show the difference in effects, if any, between hand-feeding and self-feeding the same ration mixtures for growing and fattening pigs. Questions regarding the practicability of using self-feeders have been asked by people interested in raising pigs. To be able to answer these questions with intelligence, this investigation was carried out.

Review of literature

A study of the literature showed that most of the investigations in this line in the United States were on hand-feeding vs. self-feeding, free choice, or "cafeteria" style. In the experiment reported in the present paper self-feeding, no choice, is the subject of study and this method is compared with hand-feeding, the popular method of giving hog rations.

In one test reported by the Arkansas Experiment Station, as reviewed by Carrol and Foster (1927), approximately three times as much labor was required to hand-feed pigs as to self-feed them.

Ashbrook and Gongwer (1917) gave a summary of results obtained from experiments on self-feeding and hand-feeding at num-

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erous experiment stations in the United States. This summary is as follows:

NUMBER OF PIGS	METHOD OF FEEDING	AVERAGE NUMBER OF DAYS FED	AVERAGE DAILY GAIN PER HEAD	AVERAGE DAILY FEED PER HEAD	AVERAGE AMOUNT OF FEED PER 100 POUNDS (45.4 KGM.) GAIN
			lbs.	*lbs.*	*lbs.*
262	Hand-fed	82.2	1.23 (.56 kgm.)	5.47 (2.48 kgm.)	445 (201.88 kgm.)
323	Self-fed	68.5	1.92 (.87 kgm.)	8.00 (3.63 kgm.)	417 (198.11 kgm.)

From nearly 600 pigs fed by self-feeders the results showed clearly that more rapid gains were made under this method than under the best of the hand-feeding methods.

Tomhave and Grimes, as cited by Evvard (1929), compared two lots of 15 pigs each fed for a period of 99 days. The ration was composed of corn meal, buckwheat middlings, and tankage. The self-fed lot gained 1.3 pounds (.59 kgm.) a day and the hand-fed lot, .88 pounds (.40 kgm.).

Weaver (1917), of the Missouri Agricultural Experiment Station, conducted an experiment comparing self-feeding with hand-feeding, using a mixture of corn 12 parts, and tankage 1 part. The result showed that from the standpoint of unit of gain, the hand-fed lot was only slightly better. The hand-fed lot made an average daily gain of 1.98 pounds (.90 kgm.) and the self-fed lot, 1.97 pounds (.89 kgm.). The self-fed lot, however, ate 7.85 pounds (3.56 kgm.) of feed a day whereas the hand-fed lot ate 8.25 pounds (3.74 kgm.). The amount of feed required to produce a pound of gain in the self-fed lot was 4 pounds (1.81 kgm.) and in the hand-fed lot, 4.18 pounds (1.90 kgm.).

Evvard and his associates in the Iowa Agricultural Experiment Station (1910), working on hand-feeding and self-feeding lots on pasture, found that self-fed pigs required a little less pasture for the gains made than the hand-fed ones. Self-fed pigs required 0.024 of an acre (.0097 ha.) for 100 pounds (45.4 kgm.) gain, whereas the hand-fed lot required 0.0263 acre (0.0107 ha.).

Lago (1924) compared pigs that were fed on sweet potato pasture and self-fed, free choice, on corn, rice bran, and copra meal, with hand-fed pigs on camote pasture, receiving the same kind of grains mixed in the proportion of 1 part corn, 2 parts copra meal, and 3 parts rice bran. The self-fed lot made an average daily gain of 0.47 kgm. a head and the hand-fed lot, an average of 0.28 kgm. On

the other hand, the amount of feed required to produce a unit of gain in the self-fed lot was more than that required by the hand-fed lot. Lago concluded that from the standpoint of gain the self-fed lot had the advantage, and the method was more desirable than the hand-feeding method where fast turn-over of capital in swine production is the aim.

Object of the present work

The object of the present work was to compare the two methods of feeding growing pigs, hand-feeding and self-feeding, using the same ration.

Time and place of the work

The experiment was started on December 2, 1934, and closed on June 30, 1935, thus covering a period of 210 days. The work was conducted in the Department of Animal Husbandry.

MATERIALS AND METHODS

Animals. Twelve Berkjala shotes, four barrows and eight gilts, were used in the experiment. They were about 6 months old and all were in good condition. The average weight of the pigs at the beginning of the experiment was 21.6 kilograms.

Feed and minerals. The feeds used and the price per kilogram of each at the time of the experiment were:

Fine rice bran	3.08	centavos	per	kgm.
Corn	8.20	"	"	"
Copra meal	3.60	"	"	"
Fish meal	11.00	"	"	"
Salt	2.70	"	"	"
Charcoal	6.70	"	"	"

The mineral mixture used consisted of equal parts of charcoal and common salt. Two kilograms of the mixture were added to every 100 kilograms of feed mixture used.

Shelter and other equipment. A shed made of light materials was provided for the pigs in the pasture. A self-feeder of five compartments was provided for lot II pigs. Both lots I and II were provided with drinking troughs with cross bars to prevent the pigs from wallowing in them. The drinking trough in lot 1 served also as a feeding trough.

Allotment of pigs. The pigs were divided into two lots of six pigs, care being taken to make the lots as uniform as possible in

weight, sex, and condition. Both lots received the same ration mixture. Lot I, the control lot, was hand-fed; lot II, self-fed, no choice.

Ration mixture. The standard ration mixtures of the Department of Animal Husbandry were used in this experiment. These are:

	First seventy-day period	*Second seventy-day period*	*Third seventy-day period*
Corn	15 parts	20 parts	25 parts
Rice bran	60 "	60 "	60 "
Copra meal	18 "	16 "	13 "
Fish meal	7 "	4 "	2 "
	100	100	100

Duration of the experiment. The work was carried on for 210 days, divided into three periods of 70 days each. The same allotment of pigs was used throughout the three periods.

Preparation of the feed. Sufficient stock mixture of feed was prepared to last for about a week for each lot. The self-fed pigs received their feed dry; the hand-fed pigs, in slop, water having been added to the latter ration immediately before feeding.

Feeding. Lot I was fed regularly twice a day, in the morning and in the afternoon. The pigs were allowed as much as they would readily consume. After each feeding, the trough was cleaned and filled with a fresh supply of drinking water. For lot II there was feed in the self-feeder accessible to the pigs at all times.

Weighing. The pigs were weighed, as usual, individually at the beginning and at the close of the experiment to get the initial and final weights. During the whole feeding test they were weighed weekly.

Care and management. The self-feeder was inspected twice a day, morning and afternoon, to see that the feed in each compartment of the self-feeder was available to the pigs at all times. The amount of feed placed in the self-feeder was recorded in order to get the total consumption for the week. During the rainy season stirring the feed was necessary as it absorbed moisture and would not flow freely into the trough.

During the middle part of the second period of the experiment, the weather was so warm that it was necessary to bathe the pigs once or twice a day. Near the close of the first period the camote pasture was almost exhausted so that during the second and third seventy-day periods one kilogram camote vines to every 100 kilograms live weight was given to both lots.

RESULTS

First seventy-day period

Lot I (hand-fed lot) consumed more feed than lot II (self-fed lot). It was observed that the camote pasture occupied by lot I was depleted before the end of the period. On the other hand, that occupied by lot II lasted through the second week of the second period.

It was observed that lot II pigs with feed accessible to them all the time did not all eat at the same time. Each pig came to eat at frequent intervals very regularly. At no time were all seen at the self-feeder eating simultaneously. They ate slowly and apparently took more time to masticate their feed. They made more rapid gains although they consumed less feed than did the pigs in lot I. All the pigs were in good condition and active throughout the period. There was observed, however, a difference in the two lots with regard to uniformity. Lot II pigs were more uniform in size than the pigs of lot I.

Second seventy-day period

All the pigs in the two lots were in good condition.

Lot I pigs consumed more feed than lot II. They invariably hunted first for the corn in the ration when they were fed. They did not continue in this period to be as uniform in size and condition as lot II pigs.

Lot II pigs appeared larger than those of lot I. As mentioned under "first period" the pasture for this lot lasted about two weeks longer than that of lot I.

Third seventy-day period

Lot I continued to consume a larger amount of feed than lot II. The pigs were not as uniform in size as those of lot II. In both lots, however, the pigs were active and in good condition, except one in lot I which made a rather slow gain in weight.

The pigs in lot II continued to feed in the same manner as during the first and second seventy-day periods.

DISCUSSION OF RESULTS

First seventy-day period. It may be seen in table 1 that in lot I the average daily gain in weight per pig was 0.41 kgm.; in lot II, 0.49 kgm., the difference being 0.08 kgm. Expressed in percentage, lot II was 19.51 per cent more efficient than lot I.

As to feed needed to make a unit of gain, lot I required 3.76 kgm. and lot II, 3.03 kgm. With lot I as 100 per cent efficient, lot II was 124.09 per cent.

Based on the current prices of the feeds used, the cost of feed required to make a unit of gain was 17.2 centavos in lot I and 13.8 centavos in lot II. Thus, gains in lot II were cheaper by 3.4 centavos than those in lot I.

The average ration consumed per 100 kgm. live weight of the pigs was 4.27 kgm. for lot I and 3.81 kgm. for lot II.

The depletion of the pasture of lot I at about the close of the first 70-day period, approximately two weeks earlier than the time the pasture of lot II became exhausted, was probably because the pigs in lot I did not have access to concentrate feeds except at feeding times. So these pigs were more eager to forage than those of lot II. The pigs in lot II, having access to concentrates and pasture at all times, were inclined to eat, rest, and pasture at will, never gorging themselves on concentrates and pasture at any time. This statement is supported by Robinson's (1922) findings that self-feeding made pigs utilize less forage than hand-feeding, even though the hand-fed pigs were fed all the concentrates they would clean up readily twice daily. Evvard and his associates (1910) obtained similar results.

Second seventy-day period. The average daily gain in weight per pig in the two lots in this period was the same, 0.32 kgm. for the hand-fed lot and 0.32 kgm. for the self-fed lot. It may be noted that the average daily gain in weight per pig during this period was considerably less in both lots than during the first seventy-day period. This decrease was possibly the result of change in the season affecting pasturage and also the health of the pigs. The first seventy-day period was in the cool months of December and January when the weather was favorable for the health of the pigs and when good sweet potato pasture was available. The second seventy-day period was conducted during the hot dry season when succulent grasses and camote vines were scarce.

From the point of view of the amount of feed consumed for a unit of gain in live weight, lot I required 6.47 kgm. and lot II, 5.80 kgm., showing a difference of 0.67 kgm. Expressed in percentage, lot II was 11.55 per cent better than the hand-fed lot. While both lots were making about the same rate of gain, lot I required an average daily consumption of 3.27 kgm. feed and lot II, 2.75 kgm. feed for every 100 kgm. live weight. These figures show that self-

feeding under the conditions of this test was more economical than hand-feeding. The cost to make a unit of gain in lot I was 29.6 centavos and in lot II, 26.6 centavos.

Third seventy-day period. During the third 70-day period, lot I and lot II made the same average daily gain in weight per pig which was 0.34 kgm. In feed requirement for a given gain in live weight, however, the self-fed lot was decidedly superior to the hand-fed lot. Lot II required 5.66 kgm. and lot I, 7.10 kgm. of feed for a unit of gain in weight, so that lot II was 25.44 per cent more economical than lot I.

The amount of feed consumed by lot I per 100 kgm. live weight was 2.79 kgm. and by lot II, 2.10 kgm.

Combined 210-day period. The most outstanding result obtained from the whole feeding trial was the marked and consistent economy in the amount of feed required per unit of gain in live weight by the pigs under the self-feeding method. Compared with the hand-fed lot, the self-fed lot consumed 18.65 per cent less feed per unit of gain. It appears that the saving in feed and in pasturage by the self-fed lot is the result of the conditions that made the feed available at the time the physiological need for it was manifested by the pigs, and they were able to obtain right away what they precisely needed in kind and amount. The hand-fed pigs, on the other hand, were fed concentrates only twice a day for very short periods of time so that they had to eat as much as they could each time to tide them over until the next feeding period. Between meals, even if they felt the need for concentrates, they could not have them and had to content themselves with the pasture. This condition seemed to favor over-feeding and over-grazing. Under self-feeding each pig went to feed in the self-feeder or to pasture independently and as frequently as it felt the need for the one or the other. The pasture, the shelter, or the self-feeder was generally not over-crowded at any one time. About the only time when they were together was when they rested under shade.

As may be seen in table 1, the average gain in weight per pig in lot I during the whole feeding test was 74.02 kgm. and in lot II, 80.53 kgm. With the rapidity of gain considered, lot I made an average daily gain per pig of .35 kgm. and lot II, .38 kgm., showing that more rapid gains were made when pigs were self-fed than when hand-fed. Expressed in percentage, the self-fed lot gained 8.79 per cent faster than the hand-fed lot.

The average ration consumed per 100 kgm. live weight of the pigs in lot I was 3.39 kgm. and in lot II, 2.84 kgm.

As might be expected, though both lots were on the same ration, the feed cost per unit of gain was less for the self-fed lot. To make a unit of gain, lot I required an average for the whole feeding test of 26.0 centavos worth of feed and lot II, 21.1 centavos.

One other interesting result obtained in the experiment was the difference in the appearance of the pigs in the two lots. The pigs in lot II were more uniform than those in lot I. The two extreme individual weights of the pigs in lot I at the end of the experiment were 70.4 kgm. and 113.1 kgm., or a difference of 42.7 kgm.; in lot II the smallest pig weighed 89.0 kgm. and the largest, 110.8 kgm., a difference of only 21.8 kgm. A greater uniformity in development was apparently attained when each pig in the lot was given the opportunity to feed, rest, or pasture at will, that is, activated largely by an urge from within instead of by strictly regulated circumstances. In other words, self-feeding appears to embody the advantages of both collective and individual feeding, whereas hand-feeding pigs encourages competition and struggle for existence. The effect of this struggle becomes more marked if no effort is made to give the smaller or weaker pigs an equal opportunity to get their share of the ration. It was also observed that the pigs in the self-fed lot were less rangy than those in the hand-fed lot.

SUMMARY AND CONCLUSIONS

1. A comparison of the efficiency of the two systems of feeding studied from the standpoint of economy, or the amount of feed required to make a unit of gain, showed that the self-feeding method was 24 per cent more efficient than the hand-feeding method during the first seventy-day period when the pigs had access to camote pasture; 11.5 per cent more efficient during the second seventy-day period when they were practically without grass or camote pasture; and 25.4 per cent more efficient during the third seventy-day period when grass pasture became available with the advent of the rainy season. The average efficiency of the self-fed lot during the entire 210-day period was 23 per cent more than the hand-fed lot.

2. From the viewpoint of rapidity of gain, self-feeding was 20 per cent better than hand-feeding during the first seventy-day period, and practically the same in the second and third periods. For the whole feeding test, self-feeding was 9 per cent better than hand-feeding.

3. The average cost for each unit of gain of the self-fed lot for the 210-day period was 21.1 centavos; for the hand-fed lot, 26 centavos.

4. With the average marketable size of the Berkjala as 80 kilograms, self-feeding would enable the hog producer to market his pigs approximately two weeks earlier than is possible under hand-feeding.

5. As indicated by results obtained in this study, pigs raised and fattened under the self-feeding method have a tendency to be more uniform in growth and development than those under hand-feeding.

6. Self-feeding rations should be used in preference to hand-feeding where conditions are such as to permit liberal feeding.

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TABLE 1

Summary of results of the experiment

	LOT I	LOT II
First seventy-day period		
Number of pigs	6	6
Duration of the experiment in days	70	70
Average initial weight in kgm.	21.55	21.70
Average final weight in kgm.	49.95	55.82
Average daily gain a pig in kgm.	0.41	0.49
Average ration per 100 kgm. live weight in kgm.	4.27	3.81
Average amount of feed consumed in kgm.	106.83	103.25
Feed consumed per kgm. gain in kgm.	3.76	3.03
Feed cost per kgm. gain in centavos	17.2	13.8
Second seventy-day period		
Number of pigs	6	6
Duration of the experiment in days	70	70
Average initial weight in kgm.	49.95	55.82
Average final weight in kgm.	72.03	78.47
Average daily gain a pig in kgm.	0.32	0.32
Average amount of feed consumed in kgm.	142.83	131.42
Average ration per 100 kgm. live weight in kgm.	3.27	2.75
Feed consumed per kgm. gain in kgm.	6.47	5.80
Feed cost per kgm. gain in centavos	29.6	26.6
Third seventy-day period		
Number of pigs	6	6
Duration of the experiment in days	70	70
Average initial weight in kgm.	72.03	78.47
Average final weight in kgm.	95.57	102.23
Average daily gain a pig in kgm.	0.34	0.34
Average amount of feed consumed in kgm.	167.17	134.50
Average ration per 100 kgm. live weight in kgm.	2.79	2.10
Feed consumed per kgm. gain in kgm.	7.10	5.66
Feed cost per kgm. gain centavos	33.3	26.4
Combined two hundred ten-day period		
Number of pigs	6	6
Duration of the experiment in days	210	210
Average initial weight in kgm.	21.55	21.70
Average final weight in kgm.	95.57	102.23
Average daily gain a pig in kgm.	0.35	0.38
Average amount of feed consumed in kgm.	416.83	369.17
Average ration per 100 kgm. live weight in kgm.	3.39	2.84
Feed consumed per kgm. gain in kgm.	5.63	4.58
Feed cost per kgm. gain in centavos	26.00	21.10

INFLUENCE OF EARTHQUAKES ON THE HATCHABILITY OF INCUBATING EGGS [1]

F. M. Fronda
Of the Department of Animal Husbandry

Numerous inquiries have been received as to whether there is any basis for a popular belief in the Philippines that incubating eggs when overtaken by an earthquake will fail to hatch. In the absence of supporting data, various explanations have been offered, of which two of the commoner ones are as follows:

1. Because of the strength of the earthquake, the egg is so badly shaken that some of the blood vessels of young embryos are cut, resulting in hemorrhage and death.

2. Some observers think that such eggs fail to hatch because the hen leaves the nest in her panic and refuses to set again on the eggs.

At least on the question of mechanical effect of shaking on the incubating eggs, the recent earthquake on August 20, 1937, offered a good opportunity to determine the correct answer to this question.

Incubation data from three different farms were collected for use in this study. These farms are designated A, B, and C. Four separate incubation reports were supplied by farm A, three by farm B, and four by farm C, thus making a total of eleven separate incubation reports. The ages of the eggs when they were overtaken by the earthquake varied from one day to seventeen days.

All of these incubators, except one from farm A, No. A-4, were in operation on August 20, 1937 when an earthquake of intensity VI-VII at Manila [2, 3] rocked Luzon. Incubator No. A-4 was in operation on September 17, 1937, when there was an earthquake at about 2:00 o'clock in the morning. This earthquake had an intensity of III at Santa Cruz, Laguna,[2] and was comparatively much weaker than that of August 20 which was strong enough to cause the destruction of a number of buildings in Manila and in some towns of Laguna and Tayabas.

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[1] Experiment Station contribution No. 1217. Received for publication November 18, 1937.

[2] According to a letter from Father Miguel Selga, Director of the Weather Bureau, Manila.

[3] According to Rossi-Forel scale of earthquake intensities, intensity III is a very feeble shock; intensity VI is a fairly strong shock; and intensity VII is a strong shock.

The data gathered for use in this study are given in table 1. By reference to this table, it may be seen that the eggs rocked by the earthquake varied in age from one day to seven days. Incubator No. B-3 was started in the morning of August 20 and the earthquake occurred at about 8:00 o'clock in the evening of that day. Incubator Nos. A-3 and C-4 were in operation for three days; No. C-3, five days; B-2, seven days; A-4, nine days; C-2, eleven days; A-1 and A-2, twelve days; B-1, fifteen days; and C-1, seventeen days.

The number of eggs contained in each incubator ranged from 115 in incubator No. A-1 to 483 in incubator No. B-2. The total number of eggs rocked by the earthquake was 3,420. The eggs in incubator No. A-1 were mixed, mostly of Los Baños Cantonese, Nagoya, and S. C. White Leghorn; those in incubators A-2, A-3, and A-4 were all Los Baños Cantonese; those in incubators B-1, B-2, and B-3 were mixtures of S. C. White Leghorn, Los Baños Cantonese, Nagoya, and Rhode Island Red; while those in incubators C-1 and C-2 were Nagoya, and those in C-3 and C-4 were mixtures of Los Baños Cantonese and Nagoya.

Of the 3,420 eggs in the incubators overtaken by an earthquake, 2,931, or 85.70 per cent was fertile. Because the object of this study was to determine the effect of an earthquake on the hatchability of incubating fertile eggs, all figures of hatchability given in table 1 were based on the fertile eggs only.

Effect on hatchability. By reference to table 1, it may be seen that the hatching results obtained from all the incubators involved are apparently normal. The average figures given in the last column are very much better than the average hatching results obtained in five incubators in farm A operated immediately before and after the earthquakes of August 20 and September 17, 1937. In these five incubators an average hatch, based on fertile eggs, of only 55.57 per cent was obtained, whereas the average hatchability of all the fertile eggs included in this study was 72.09 per cent. In a study to determine the best season of hatching eggs made in this College (Resananda, 1924)[4] the hatchability of fertile eggs reported was 59.45 per cent in August and only 45.80 in September. In the present study, the hatchability in the eleven incubators studied ranged from 55.67 per cent in incubator No. A-1 to 85.61 per cent in incubator No. B-1.

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[4] RESANANDA, NAI THONGDEE. 1924. Determination of the best season for hatching eggs in the Philippines. The Philippine Agriculturist 13: 81–91.

Eggs overtaken during the first week of incubation. To determine whether an earthquake shock had any effect on young developing embryos, the eggs in the eleven incubators studied were classified according to age. It may be seen in table 1 that the eggs overtaken during the first week were those contained in incubators No. A-3 (three days old), B-2 (seven days old), B-3 (one day old), C-3 (five days old), and C-4 (three days old). Those overtaken during the second week of incubation were contained in incubators No. A-1 and A-2 (both twelve days old), A-4 (nine days old), and C-2 (eleven days old) and those caught during the third week of incubation were contained in incubators No. B-1 (fifteen days old) and C-1 (seventeen days old).

Whatever adverse effect an earthquake shock might have on the young embryos of incubating eggs should be expected in the first week of incubation when the tiny blood vessels are beginning to spread out and, hence, would presumably be most susceptible to violent shaking. From the figures given in table 1 (see incubators Nos. A-3, B-2, B-3, C-3, and C-4) it may be seen that the average mortality of the embryos of these eggs during the first week varied from 0 to 4.96 per cent, or an average of only 2.06 per cent; that during the second week varied from 2.88 to 9.09 per cent or an average of 5.74 per cent; and that during the third week varied from 12.05 to 28.40 per cent, with an average of 17.17 per cent. The average hatchability of all the fertile eggs in these five incubators was 75.03 per cent. All of these figures are much higher than the normal figures previously reported (Resananda, 1924).

Eggs overtaken during the second week of incubation. In this group the eggs in incubators Nos. A-1, A-2, and C-2 were included. The average mortality of these eggs during the first week of incubation was 2.60 per cent, that during the second, 6.16 per cent, and that during the third, 28.31 per cent. The average hatchability of these eggs was 62.93 per cent. It will, therefore, be seen that those figures are well within the normal range, although the mortality figures were a little higher and the average hatching result was 10 per cent lower than those of eggs that were overtaken by the earthquake during the first week of incubation.

Eggs overtaken during the third week of incubation. Only two incubators (Nos. B-1 and C-1) were included in this group. The average mortality of the embryos of the eggs in these incubators during the first week was 4.21 per cent; during the second, 3.69 per cent; and during the third, 14.05 per cent. The average hatch-

ability of this group of eggs was 76.05 per cent. With the exception of the higher mortality during the first week of incubation when the eggs have not yet been rocked by the earthquake, the other figures are much better than those obtained from the eggs overtaken by earthquake during the second week of incubation. The hatching results obtained from this group of eggs are about the same as those obtained from the eggs caught by the earthquake during the first week of incubation.

These figures show that no ill effect upon the eggs that were overtaken by the earthquake resulted. The higher hatching results obtained from these incubators may have been due to better quality of the eggs incubated or to the care in manipulation. However, an interesting question arises: Might the fairly vigorous shaking of the eggs have exerted some beneficial effect on their hatchability? This unexpected development would be a fit subject for future investigation.

SUMMARY AND CONCLUSIONS

The hatching results of eggs contained in eleven incubators that had been overtaken by a fairly severe earthquake are reported in this paper. These figures may be summarized as follows:

1. The hatching results obtained from the eleven incubators included in this study were apparently normal.

2. The eggs that were overtaken by an earthquake during the first week of incubation hatched just as well as, if not better than, those not overtaken by an earthquake.

3. No adverse effect was observed on the hatching results of eggs overtaken by an earthquake during either the first, or second, or third week of incubation.

4. From these results, it is safe to conclude that even an earthquake with intensity VII did not produce any adverse mechanical effect on the hatchability of the eggs. The reaction of setting hens to earthquake shocks is not included in the present findings.

TABLE 1

Hatching data of eleven incubators overtaken by an earthquake

FARM	A				B			C				ALL INCUBATORS
Incubator No.	1	2	3	4	1	2	3	1	2	3	4	11
No. of eggs	115	236	285	275	468	483	468	300	278	256	256	3,420
Age of eggs, days ..	12	12	3	9	15	7	1	17	11	5	3	1–17
Per cent D_1	0	1.61	1.20	1.90	0.76	0	1.00	7.66	6.20	4.96	3.12	2.58
Per cent D_2	3.09	7.53	4.80	6.63	2.02	2.88	3.46	5.36	7.85	9.09	8.48	5.56
Per cent D_3	41.24	26.34	28.40	18.48	11.62	16.79	15.80	16.47	17.35	12.81	12.05	19.76
Per cent H [a]	55.67	64.52	65.60	72.98	85.61	80.33	79.75	70.50	68.59	73.14	76.34	72.09

[a] Based on fertile eggs

PUBLISHED CONTRIBUTIONS OF THE COLLEGE OF AGRICULTURE: XV [1]

B. M. GONZALEZ
Dean, College of Agriculture

After almost thirty years of constant labor on the part of the College staff, the institution has unexpectedly won for herself public recognition in her field of endeavor. No less a personage than the Chief Executive of the Commonwealth openly commended its accomplishments along the line of research and scholarship, and, seemingly to prove his sincerity, topped it off by inserting in the 1938 budget a substantial sum for improvement of research facilities in the College—all done spontaneously and without any campaign or solicitation on the part of this institution.

Independently, and also spontaneously, the Government Survey Board, an organization charged with the task of coördinating the various functions of government in order that the greatest efficiency and accomplishment for a given outlay of funds may be attained, is now sponsoring a measure calculated to consolidate at the College of Agriculture the basic agricultural research activities of the Philippine Government including lines of work in the field of plant industry, animal industry, and forestry.

A section of the press, representing in a measure public opinion, has also openly advocated the transfer of the State University to Los Baños, giving as the chief argument for this move the wholesome atmosphere conducive to scholarship pervading the institution's campus.

Never before has the College enjoyed such wholesale and spontaneous recognition for its labors.

Modestly and painstakingly, as befits scientific workers, the College constituency has followed the path of duty lying before it, unflinchingly pursuing its task, and quite unmindful of the vicissitudes that attended the first steps, which were painfully slow and apparently inconsequential at the beginning. The history of the institution is quite characteristic of the progress of scientific work anywhere—slow, steady, but ever advancing and gathering momentum with time.

[1] General contribution No. 614. For earlier contribution lists see previous volumes of this journal. No. XIV of the series appears in The Philippine Agriculturist 25 (1937): 868–875.

Those of us who are still on the grounds and fortunate enough to be the recipients of the plaudits must not forget, not only those who have preceded us and have builded solidly, but also that we are only casual participants in an interminable relay race. We are not permitted to lay down the baton but must carry on actively until our allotted measure is successfully completed and until more vigorous shoulders are ready to take up our tasks and relieve us.

It is heartening to any worker to enjoy commendations for work well done, for even votaries of science have the common frailties of human beings. This, the fifteenth list of the yearly intellectual output of the College, we offer, therefore, as a humble expression of our sincere appreciation for the honors that have lately been heaped on our institution.

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(1179) UICHANCO, L. B., AND ROMULO B. GINES. 1937. A biometrical study of the adult components of Philippine locust swarms. The Philippine Agriculturist **26**: 237–289. *Charts 1–10.*

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V. MISCELLANEOUS CONTRIBUTIONS

(15) BLANDO, JOSÉ B. (translator) 1937. Mount Maquiling and its present volcanic emissions *by* ENRIQUE ABELLA Y CASARIEGO. The Philippine Agriculturist **26**: 199–221.

(16) UICHANCO, LEOPOLDO B. (translator) 1937. A nineteenth century Spanish diplomat's view of Philippine colonial policy. The Philippine Agriculturist **26**: 225–228.

(17) UICHANCO, LEOPOLDO B. (translator) 1937. Los Baños and vicinity one hundred and forty years ago *by* JOAQUIN MARTINEZ DE ZUÑIGA. The Philippine Agriculturist **26**: 477–484.

COLLEGE AND ALUMNI NOTES

The officers of the Student Body, College of Agriculture, for the second semester, 1937-1938 are: Lorenzo Zialcita, president; Ascario G. Tuason, vice-president; Valentin Cedillo, secretary; and Ramon G. Mercado, treasurer.

The meeting of the Los Baños Biological Club on January 27 featured a lecture by Dr. Tyozaburo Tanaka on "Achievements in horticultural research in Japan" and a moving picture presentation of life and scenes in modern Japan, given through the courtesy of the Reverend H. Yamanouchi.

The Los Baños Corps of Cadets honored the deans and faculties of the College of Agriculture and the School of Forestry with an evening parade on January 28.

The third public speaking contest for students in agriculture was held in the College auditorium on January 22, with entries from eight high schools. The winners were: first prize, Perfecto Rubio, Luis Palad High School; second prize, Pablo Aguila, Batangas High School; and third prize, Maria Pascua, Batac Rural High School.

The Hon. Fujinuma, member of the Japanese House of Peers, and Hon. Kiyoshi Uchiyama, Japanese Consul-General, were campus visitors on January 14.

The senior class organization held its annual ball on January 15 at the Seniors' Social Garden. Dean Gonzalez was the guest of honor.

The faculty conference for the improvement of teaching was held on February 8 from ten to eleven o'clock in the morning, in which Professors I. Panlasigui and A. Isidro read papers. The conference was followed by a luncheon given by Dr. and Mrs. L. G. Gonzalez in honor of the President's Committee for the Improvement of Teaching.

Miguel Manresa, Jr., '37, was recently appointed assistant in agricultural zoölogy at this College. Mr. Manresa was formerly an officer on active duty in the Philippine Army.

Dean B. M. Gonzalez spoke on farming as an occupation at a convocation in Tayabas High School on January 14.

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